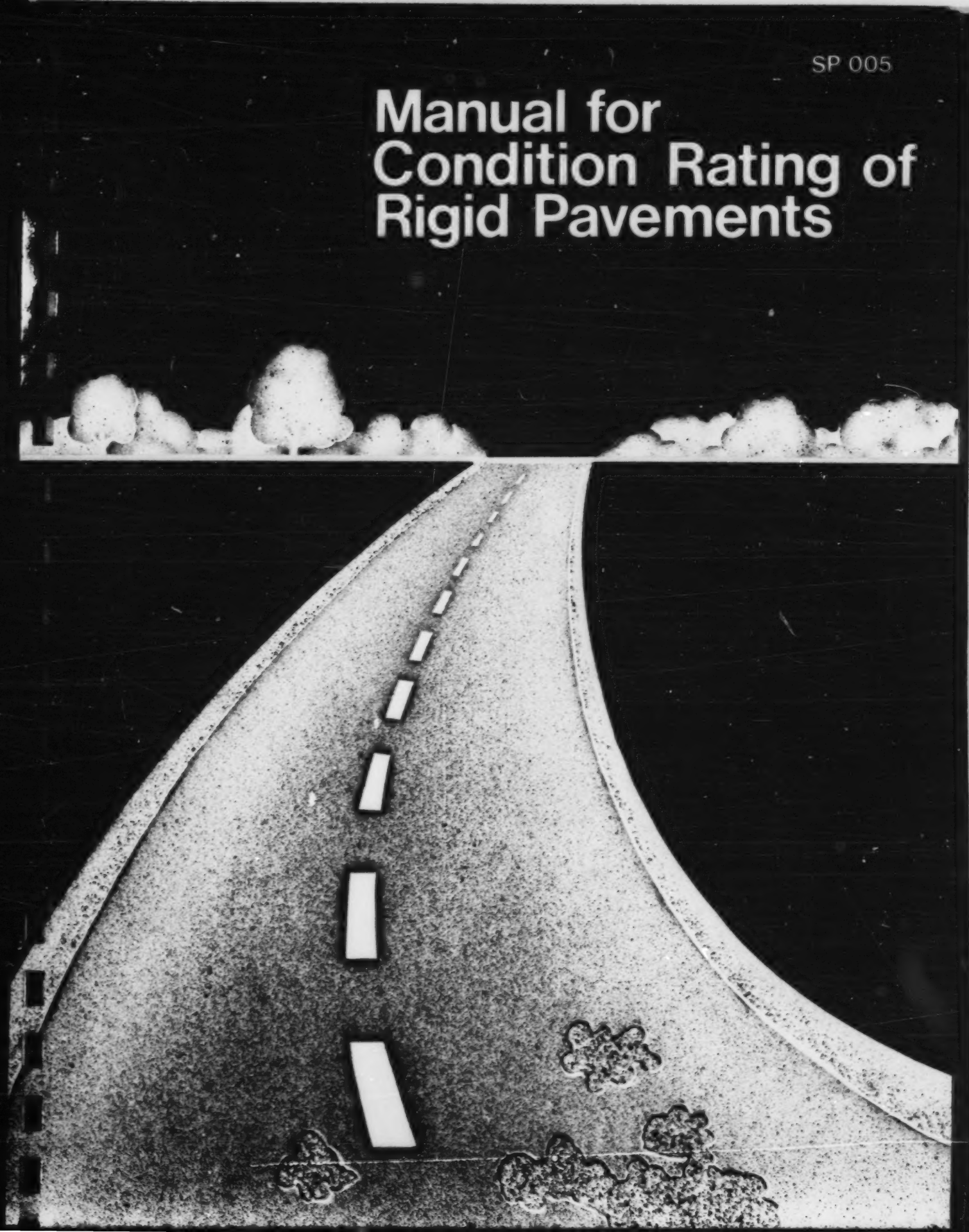
SP 005

Manual for Condition Rating of Rigid Pavements



Ontario

Ministry of
Transportation and
Communications

Manual for Condition Rating of Rigid Pavements

Distress Manifestations

G.J. Chong
Research Engineer

W.A. Phang
Principal Research Officer
Research and Development Branch

G.A. Wrong
Pavement and Foundation Design Section
Highway Engineering Division

Published by
The Research and Development Branch
Ontario Ministry of Transportation and Communications
Hon. James W. Snow, Minister
H.F. Gilbert, Deputy Minister

Published without prejudice
as to the application of the findings.
Crown copyright reserved; however, this
document may be reproduced for non-commercial
purposes with attribution to the Ministry.

For additional copies, write
The Editor
Research and Development Branch
Ontario Ministry of Transportation and Communications
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8

Second Edition
April 1982

ISBN 0-7743-8068-3
ISSN 0-226-9414

CONTENTS

1. **Introduction** 1

2. **Pavement Surface Condition Rating Scheme** 2

3. **Procedure for Pavement Evaluation** 4

4. **Riding Quality (Riding Comfort)** 5

5. **Distress Manifestations** 6

   5.1 Surface Defects 7

   5.2 Surface Deformation 17

   5.3 Joint Deficiencies 23

   5.4 Cracking 30

   5.5 Spalling 49

   5.6 Miscellaneous Distresses 54

6. **Maintenance** 56

   Appendix A. A Guide for Completing the "Rigid Pavement Condition Evaluation Form" 59

   Appendix B. A Guide for Completing "Pavement Condition Report Forms" 62

1. Introduction

1. Introduction

Rating of pavement surface condition is used in one form or another by most highway authorities as a measure of the ability of the pavement to continue to provide required service to the public. The more important uses for condition ratings are their use in determining deficiencies, inadequacies, remedial measures, fiscal needs, and in programming. The surface condition rating scheme used in Ontario is based on two interrelated measures – riding quality and distress manifestations.

Riding quality, while it is a subjective measure depending on personal opinion, on regional bias, and on observer experience, can be measured quantitatively by mechanical devices such as Roughometers and Profilometers. Distress manifestations have not previously been quantified, but this is needed if more meaningful use is to be made of condition ratings. Distress manifestations are categorized and illustrations of each category are provided to lend uniformity to reporting and interpretation. In addition, descriptions of the density of occurrence and the severity of the particular distress manifestation are made to conform with standard words which express the relative density or severity on a scale which may be quantified from 1 to 5. Examples of use of these descriptions of distress manifestations are given, such as 'slight longitudinal cracks occurring at frequent intervals over the section.' In this example, the words 'slight' and 'frequent' are the standard words which correspond to Numbers 2 and 3 on the severity and density scales. Guidelines and photographs are provided to control usage of the standard words.

Probable causes of each distress manifestation are presented, together with comments on progressive deterioration or other behaviour which might affect remedial treatment.

Although the purpose of this manual is to describe distress manifestations of the pavement, possible matching remedial measures are suggested under each distress manifestation. However, it should be understood that the possible remedial measures listed against a deficiency might not necessarily be the most effective maintenance alternative, nor will these measures necessarily effectively correct the cause or causes of the distress. That is, the listed remedial measure may only be as an expedient maintenance treatment to slow the deterioration.

2. Pavement Surface Condition Rating Scheme

2. Pavement Surface Condition Rating Scheme

The rating scheme devised and used in Ontario at present is shown in Table B-1 of the Appendix. It presents a rating scale of 0 to 100 and the locations on this scale for separating different timing and types of remedial action together with their corresponding descriptions of surface condition in terms of riding quality, surface defects and deformation and the severity, extent and type of crack distress. This scheme is valid; however, more value can be obtained from Condition Reports if a formalized and uniformly-worded description of the distress manifestations is implemented. Such descriptions aid in decisions regarding the choice of remedial treatment which has the best probable chance of success, add to performance evaluation of different pavement designs, allow identification of specific problems or weaknesses, and permit quantitative analysis of type, extent and location of distress manifestations.

Condition rating consists of a rater evaluating two different physical parameters: the riding quality of the pavement surface, and the extent and severity of distress manifestations. The two physical parameters are interrelated by reason that some distress manifestations result in surface deformation which then cause a reduction in riding quality. However, rougher pavements, in turn, cause vehicles to produce higher dynamic wheel loads, thus increasing stresses, strains, and deflections and pumping motions and hastening deterioration. Not all distress manifestations are accompanied by surface deformation. The type of distress and the extent and severity of occurrence are all very useful indicators of structural inadequacy, material deficiency, and probable rate of subsequent deterioration.

Riding quality of the pavement is measurable by means of mechanical devices such as Roughometers and Profilometers. The roughness is expressed as a number of millimetres of vertical motion per kilometre. However, such devices are too slow and inconvenient for regular usage and must be checked and calibrated at frequent intervals, thus making them expensive and, at times, unavailable. Since riding quality is a perceived measure, it is quite practical for the rater to attempt to evaluate ride quality. This ability improves with experience, but there is a need for a rater to be aware, at all times, of the condition and characteristics of the vehicle which he is using.

Distress manifestations may be grouped under five main headings, i.e., surface defects, surface deformation, joint deficiencies, cracking and miscellaneous distresses. In a general way, it can be said that surface defects result from a combination of construction circumstances such as mix proportioning, the aggregates used, the joint construction and materials, and on traffic, the environment, and age. In the same way, it can be said that surface deformation results from inadequate structures, from consolidation of the materials comprising the structure and subgrade, from loss of materials comprising the structures and subgrade through pumping action, and from embankment slip failures. It can also be said that cracking results from traffic loading, or from thermally- or environmentally-induced forces. The different distress manifestations have been assigned names, which are listed in Figure 1. Each type of distress is evaluated in terms of the extent or density of occurrence and in terms of severity. Uniform word descriptions are suggested to correspond with each category of density or severity.

Condition ratings generally apply to whole contract or project lengths involving many kilometres of pavement. To make the rating reports more useful, condition ratings of subsections may be undertaken. A preliminary evaluation of ride quality may enable the rater to identify subsections with substantially different qualities, and the project may be subdivided by such changes; however, it is suggested that subsections should be between 2 km and 5 km in length. Occasionally, newer pavements exhibit essentially uniform conditions throughout, and there is no need to subdivide the project length.

Pavement condition ratings are to be carried out between the late spring and fall. Pavement condition ratings are needed at regular intervals so that management is aware of changing conditions and can plan maintenance and rehabilitation with confidence, especially maintenance programs as a preventive measure. The completeness and uniformity of condition reports should lead to increased confidence in planning.

Pavement Distress Manifestation	Evaluation		
	Severity	Density	Other Characteristic
Surface Defects • Polishing • Loss of Coarse Aggregate • Pot-Holes • Scaling • Ravelling			
Surface Deformation • Faulting (Stepping) • Settlement (Sagging)			
Cracking • Longitudinal • Meandering • Corner • 'D' • Transverse • Diagonal • Edge Crescent • Miscellaneous			
Spalling • Joint • Crack			
Miscellaneous Distresses • Lane Separation • Slab Warping • Wheel-Track Wear			
Maintenance • Full-Width Joint Repair (with Concrete or Asphalt) • Full-Depth Pressure Relief Joint • Precast Slab • Cold-Mix Patching • Saw Cut and Hot-Mix Patching • Full-Width, Hot-Mix Patching			

Figure 1. List of Distress Manifestations

3. Procedure for Pavement Evaluation

3. Procedure for Pavement Evaluation

Step 1

To assess Riding Comfort Rating, drive over the pavement at posted speed. This step will familiarize the rater with topography, special structures, etc. and will assist in establishing subsections to be rated individually from the work project. However, subsections must have a minimum length of 2 km.

Step 2

After establishing the subsections to observe distress, drive over the pavement in ONE direction at a maximum speed of 50 km/h for distress evaluation. Minimum one stop per section shall be made to examine distress type and severity, particularly surface conditions and surface deformation. More stops shall be made if condition is found to be varied (perhaps two or three stops per section).

If pavement exhibits essentially uniform conditions throughout, and there is no need to subdivide the work project, drive slowly (not exceeding 50 km/h) over pavement in ONE direction and make stops as necessary to examine type and severity (perhaps two stops per work project).

Step 3

Use the pavement distress manifestation classifications and the evaluation terminology, according to the Condition Rating Manual. It is strongly recommended that the distress manifestation checklist be used while in the field.

4. Riding Quality (Riding Comfort)

4. Riding Quality (Riding Comfort)

Riding quality of a pavement is the degree of riding comfort which the pavement section in question provides to the travelling public. To describe the riding quality, the evaluator should use the standard RTAC Present Performance Rating procedures. The rater drives over the pavement section at posted speed and, having done so, classifies the pavement's riding comfort according to the description given in Table 1.

It is important that the rater should try not to be influenced by the appearance of the pavement surface when rating riding comfort; only the riding comfort the pavement provides to the rater should be considered relevant. It is also important that the rater should try not to be influenced by the pavement's class when rating riding comfort. The class of highways being rated should be considered irrelevant.

Table 1. Riding Comfort Rating Guide for Rigid Pavement

RCR*	Uniform Description of Riding Comfort at Posted Speed	Guidelines
10-8	Excellent	Smooth and pleasant ride
8-6	Good	Comfortable
6-4	Fair	Uncomfortable
4-2	Poor	Very rough and bumpy
2-0	Very poor	Dangerous at 80 km/h

*Note: Riding Comfort Rating (RCR) is a measure determined by a Panel of Raters or, alternatively, by measurement with a mechanical device which is correlated with a Panel of Raters.

5. Distress Manifestations

Introduction	6
5.1 Surface Defects	7
5.2 Surface Deformation	17
5.3 Joint Deficiencies	23
5.4 Cracking	30
5.5 Spalling	48
5.6 Miscellaneous Distresses	54

Introduction

A distress in a pavement caused by vehicle loads or by material forces generated by changes in moisture, temperature, sunlight, and other environmental consequences, visibly manifests itself as a surface defect, as a deformation, joint deficiencies, or as a crack.

Each type of distress manifestation named in this text is listed under one of five subgroups:

- **Surface Defects**
- **Pavement Deformation**
- **Joint Deficiencies**
- **Cracking**
- **Spalling**
- **Miscellaneous Distresses**

Each defect is described and illustrated by one or more photographs. Possible causes of the defect are listed, and an example of the use of the uniform word description is presented.

To prepare a pavement condition report, the rater must first determine the extremities of each subsection within the project to be reported on, and within each subsection identify the types of distress manifestations present, and then evaluate the extent and severity of their occurrence. To aid the rater in this task, the Evaluation Form in Figure A-1 (Appendix A) is first consulted, and then the following sets of photographs (Figures 2 through 63) of distress manifestations are used to identify the types of distress present. Tables 2 through 18 give the uniform word descriptions for density and severity of occurrence of the different types of distress which must be used if analysis is to be successful.

Distress Manifestations

5.1 Surface Defects

Polishing 7
Loss of Coarse Aggregates 9
Pot-Holes 11
Scaling 13
Ravelling 15

5.1 Surface Defects

Polishing

Description: Polished appearance of pavement surface due to glazing of coarse aggregate particles in mix (Figure 2).

Possible Causes: Wear resistance of coarse aggregate particles greater than mortar, thus exposing them to glazing action of traffic. If highly polished, poor skid resistance may result.

Severity: See Table 2.

Density: See Table 3.

Example: Moderate polishing of surface at intermittent intervals.

Possible Remedial Measures: In case of very severe polishing, thin hot-mix resurfacing or transverse grooving may be necessary. Others which may perform equally well are surface treatment, and hot or cold planing.

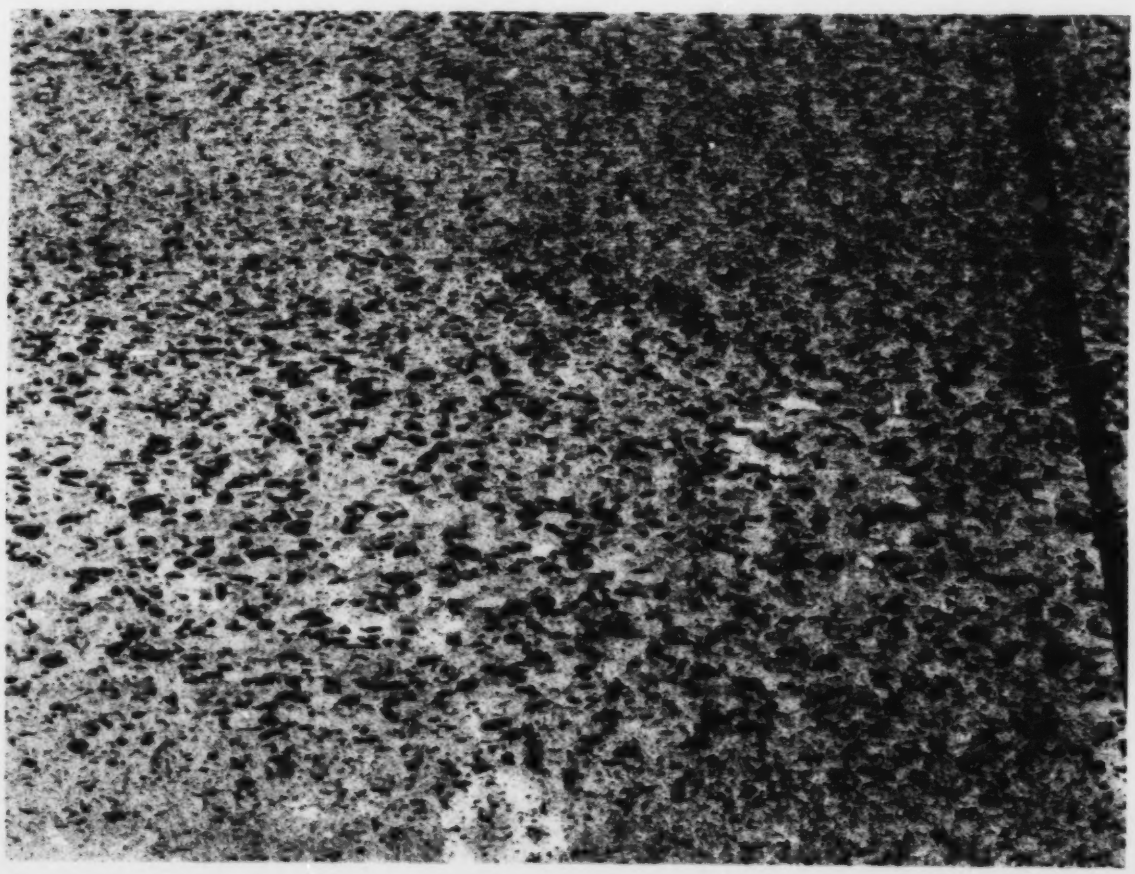


Figure 2. Polishing

Loss of Coarse Aggregates

Description: Coarse aggregate particles (>6 mm) are removed from the surface (Figure 3).

Possible Causes:

1. Lack of bond between particles and mortar due to inadequate coating.
2. Too coarse a mix and/or improper proportioning due to poor construction design and/or procedures.
3. Fracture of the particle through load or natural causes, allowing the loosened pieces to be picked out by traffic action.
4. Disintegration of particles such as chert or shale which are highly absorptive and fracture and disintegrate upon repeated freezing and thawing.

Severity: See Table 4.

Density: See Table 3.

Example: Moderate loss of coarse aggregate at frequent intervals.

Possible Remedial Measures: Hot-mix resurfacing for very severe case, or linseed oil treatment, and cement wash method.

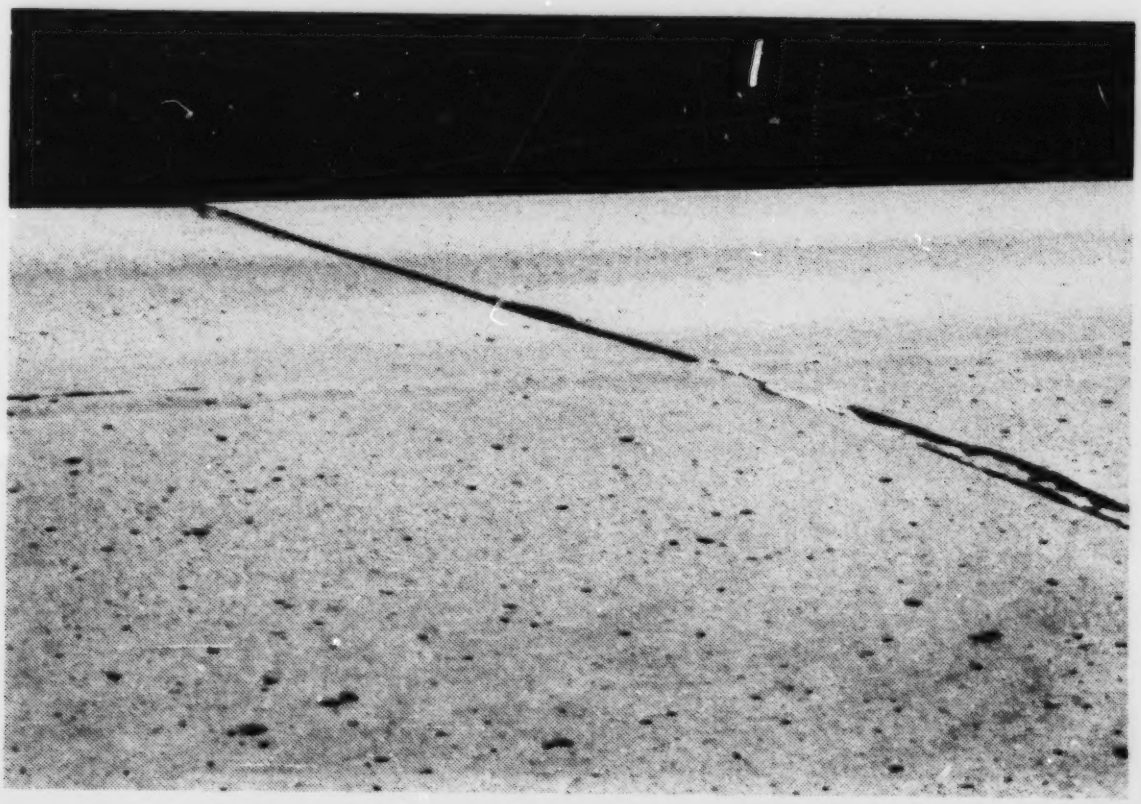


Figure 3. Moderate Loss of Coarse Aggregates

Table 4. Guide for Describing Severity of Pavement Surface Distress — Loss of Coarse Aggregate

Class	Uniform Description	Guidelines (Based on observation of appearance)
1	Very slight	Barely noticeable
2	Slight	Noticeable
3	Moderate	Having pock-marked appearance; fairly well spaced between pock-marks.
4	Severe	Having pock-marked appearance; pock-marks are closely spaced.
5	Very severe	Surface has a ravelled appearance.

Pot-Holes

Description: Holes in pavement surface unrelated to cracking or other surface defects (Figure 4).

Possible Causes:

1. Disintegration from action of traffic combined with environmental conditions and improper mix design and proportioning.
2. Oversize particles of soft aggregate or clay, or other soft foreign materials.
3. Reinforcing steel too close to the surface.

Severity: See Table 5.

Density: See Table 3.

Example: Severe pot-holings at few locations.

Possible Remedial Measures: Cold-mix maintenance patch; hot-mix patch.

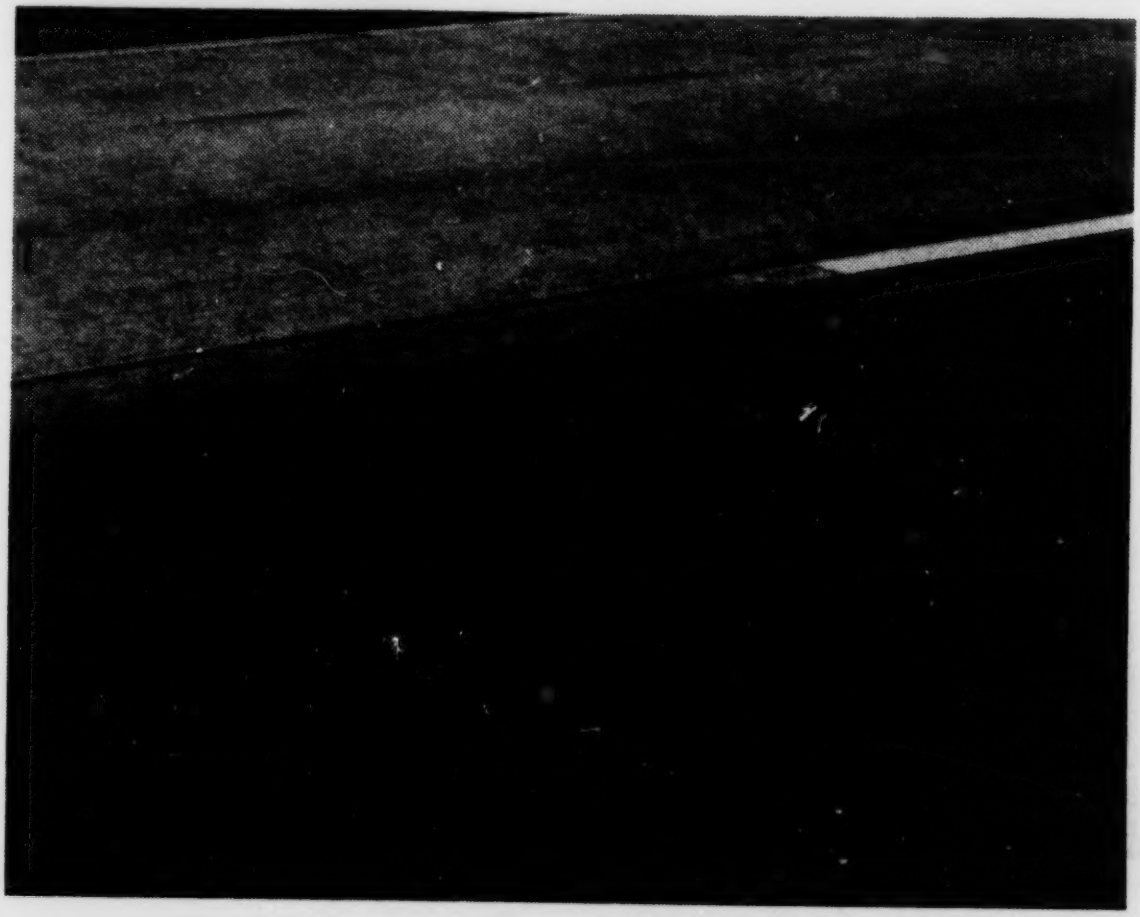


Figure 4. Severe Pot-Hole

Table 5. Guide for Describing Severity of Pavement Surface Distress — Pot-Holes

Class	Uniform Description	Guidelines (Based on observation of appearance)
1	Very slight	Barely noticeable;resembling a pop-out of coarse aggregate.
2	Slight	Disintegration of the surrounding material.
3	Moderate	Size of hole much larger than pop-out of coarse aggregate and also deeper.
4	Severe	Pot-hole over 15 cm deep and 15 cm diameter.
5	Very severe	Interfere with ridability.

Scaling

Description: Peeling away of the concrete pavement surface; may occur anywhere over the pavement surface (Figure 5).

Possible Causes:

1. Effect of freeze-thaw and/or de-icing chemicals on non-air-entrained concrete.
2. Laitance on surface due to excessively wet mixes.
3. Frost action on concrete not fully cured or weak.
4. Weakened surface caused by overfinishing.

Severity: See Table 6.

Density: See Table 3.

Example: Very severe scaling at few intervals.

Possible Remedial Measures: Thin hot-mix or cold-mix patching.

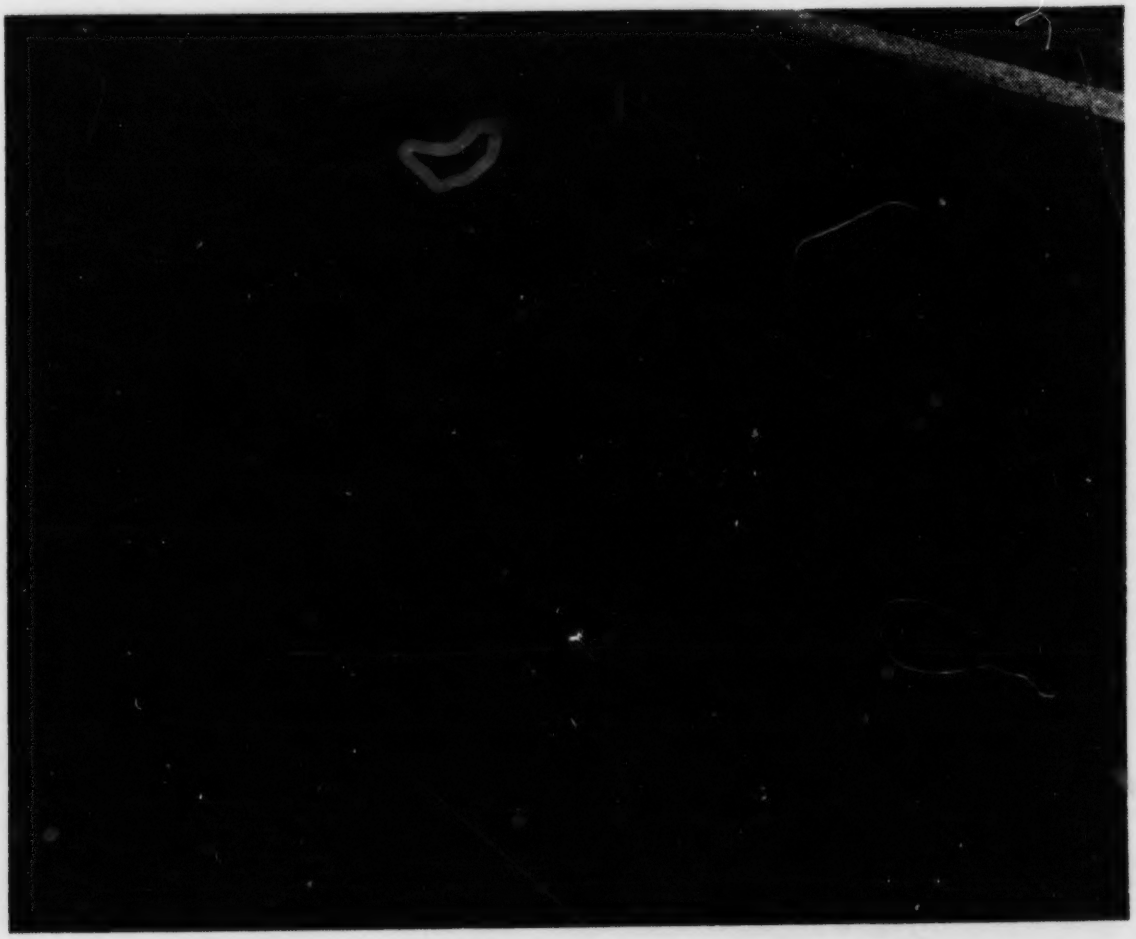


Figure 5. Very Severe Scaling

Table 6. Guide for Describing Severity of Pavement Surface Distress — Scaling

Class	Uniform Description	Guidelines (Based on observation of appearance)
1	Very slight	Barely noticeable
2	Slight	Noticeable
3	Moderate	Open texture
4	Severe	Disintegration in shallow patches closely spaced.
5	Very severe	Disintegration in shallow patches covering the whole surface area.

Ravelling

Description: Loss of fine aggregates from matrix. This is a different form of scaling and visually the characteristics are not the same. Scaling is spotty whereas ravelling is continuous over the pavement surface affected. In appearance, it is very similar to the ravelling of asphaltic pavement surface and generally appears to be the worst in the two wheel tracks (Figures 6 and 7). Therefore, to differentiate these two forms of scaling, this shall be named ravelling.

Possible Causes:

1. Poor quality fine aggregates.
2. Lack of bond between mortar and coarse aggregates.
3. Effect of freeze-thaw and/or de-icing chemicals on non-air-entrained concrete.
4. Frost action on concrete not fully cured or weak.
5. Traffic action of special nature such as studded tires.

Severity: See Table 7.

Density: See Table 3.

Example: Severe ravelling at frequent intervals in both wheel tracks.

Possible Remedial Measures: Surface treatment or thin asphalt resurfacing or asphalt patching.

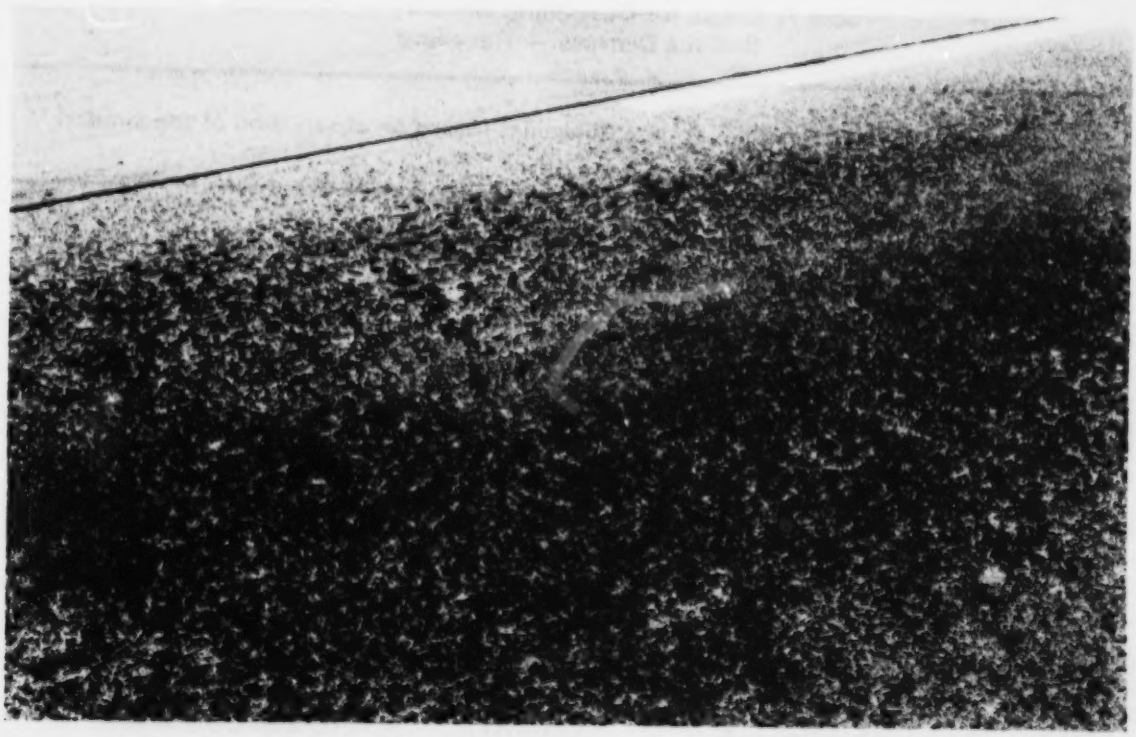


Figure 6. Moderate Ravelling

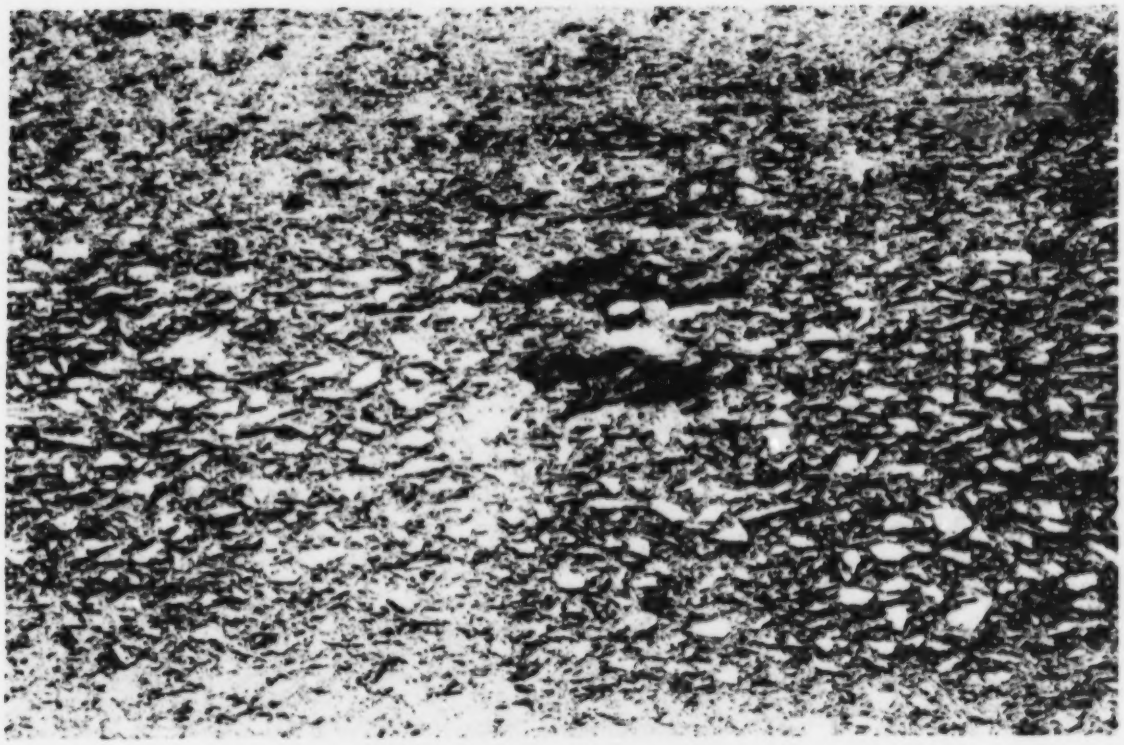


Figure 7. Severe Ravelling

Table 7. Guide for Describing Severity of Pavement Surface Distress — Ravelling

Class	Uniform Description	Guidelines (Based on observation of appearance)
1	Very slight	Barely noticeable
2	Slight	Noticeable
3	Moderate	Open texture
4	Severe	Disintegration appearance with shallow small pot-holes.
5	Very severe	Disintegration appearance with shallow large pot-holes.

Distress Manifestations

5.2 Surface Deformation

Faulting (Stepping) 17
Settlement (Sagging) 21

5.2 Surface Deformation

Faulting (Stepping)

Description: Differential vertical displacement of abutting slabs at joints or cracks creating a "step" deformation in the pavement surface. Usually the "upstream" slab is higher than the "downstream" slab (Figures 8, 9, 10 and 11).

Possible Causes:

1. A consequence of pumping (Figure 12). Significant movement of the slab under heavy load propels water under the upstream slab forward and under the downstream slab. Since the movement increases steadily as the load approaches the joint or crack, the propelling force is not as large as when the load transfers, in a very small instant, to the trailing slab. Consequently, the water under the trailing slab is ejected or propelled backwards at a higher velocity than it is propelled forward. Fines in the base material are washed back and forth under the joint or crack, but tend to build up beneath the upstream slab.
2. Lack of subgrade support.
3. Under compressive stresses, the upstream slab shatters at the bottom of the slab and rides over the downstream slab.
4. Expansion of freezing water which accumulated under the slab through capillary activity, or from surface water seeping into base and subgrade through joints or cracks, plus/or differential frost heave in poorly-drained cuts and transitions.

Severity: See Table 8.

Density: See Table 9.

Example: Moderate faulting of transverse joints (or cracks) occurs extensively in the section.

Possible Remedial Measures: Mud-jacking to restore slab support; multiple layers or hot-mix resurfacing; joint and crack sealing; base drainage by perforated pipe under pavement edge; (cold planing not yet feasible).

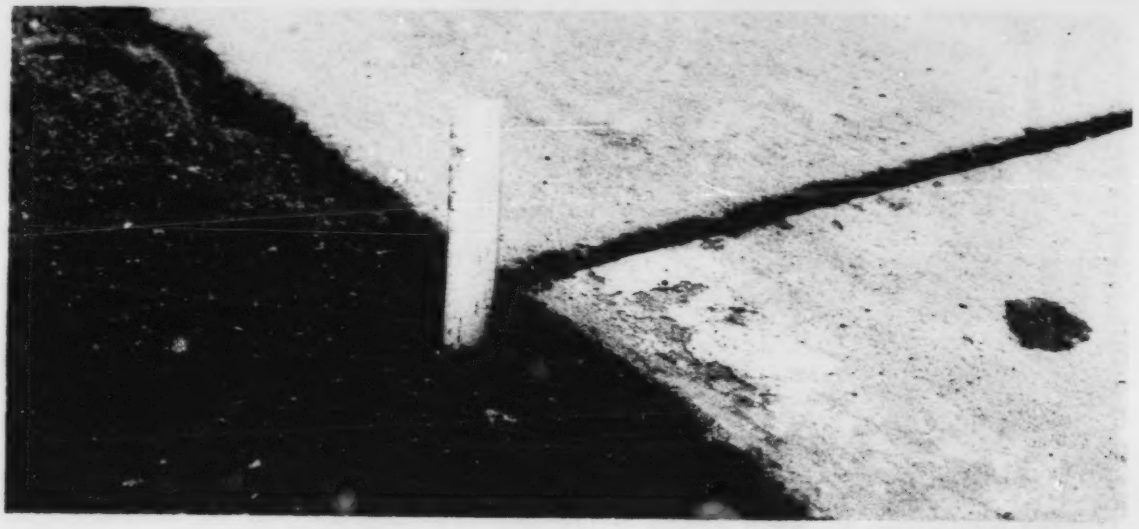


Figure 8. Severe Transverse Joint Faulting

Figure 9. Moderate Longitudinal Joint Faulting

Figure 10. Severe Transverse Crack Faulting

Figure 11. Very Severe Faulting from Frost Action

Figure 12.
Pumping of Concrete Pavement Slab at and near Transverse Joint (Note fine materials being pumped out through water action along the pavement edge both upstream and downstream from the transverse joint.)

Table 8. Guide for Describing Severity of Joint Faulting

Class	Uniform Description	Guidelines (Based on appearance and height of fault)
1	Very slight	Barely noticeable (3 mm)
2	Slight	3 mm - 6 mm
3	Moderate	6 mm - 13 mm
4	Severe	13 mm - 19 mm
5	Very severe	>19 mm

Table 9. Guide for Describing Density of Pavement Distress — Surface Deformation

Class	Uniform Description	Guidelines (Based on percent of pavement length in section affected by defect)
1	Few	<10%
2	Intermittent	10 - 20%
3	Frequent	20 - 50%
4	Extensive	50 - 80%
5	Throughout	80 - 100%

Settlement (Sagging)

Description: Longitudinal deviation of the pavement surface from its original construction profile. The change in elevation is generally in the order of greater than 2.5 cm with a wave-length of more than 3 m (Figure 13).

Possible Causes:

1. Poorly-compacted base or subgrade and/or structure backfill.
2. Differential settlement of subgrade or base materials.
3. Lack of subgrade support.

Severity: See Table 10. Severity of settlement is assessed by raters in a subjective manner based on the relative motion of a moving vehicle over the pavement. Settlement causes the vehicle, generally, to pitch and roll. The rater must evaluate the severity on the basis of his past experience. The guidelines in the table are intended to assist in developing uniformity in assessment of this defect.

Density: See Table 9.

Example: Severe settlement occurs frequently in the section.

Possible Remedial Measures: Hot-mix padding to eliminate deformation, and hot-mix resurfacing.

Figure 13. Pavement Settlement

Table 10. Guide for Describing Severity of Pavement — Settlement (Distortion)

Class	Uniform Description	Guidelines (Based on personal ride quality experience of the interaction between vehicle and pavement surface distortion)
1	Very slight	Noticeable (swaying motion).
2	Slight	Good control of the car still present for driver of vehicle.
3	Moderate	Fair control of car when driving over pavement.
4	Severe	Poor car control when driving over pavement with driver always having to anticipate settlement (distortion) ahead.
5	Very Severe	Continuous settlement (distortion) making it a dangerous situation if driving car at speed greater than 60 km/h.

Distress Manifestations

5.3 Joint Deficiencies

Joint Creeping 23
Joint Sealant Loss 25
Joint Failures 28

5.3 Joint Deficiencies

Joint Creeping

Description: Generally noticed at transverse joints. One lane's transverse joint moves ahead (or behind) the one in the adjacent lane from its original alignment straight across both lanes (Figures 14 and 15).

Possible Causes:

1. Concrete slab alternately curls and warps due to temperature and moisture differentials within the slab. This motion, combined with the horizontal thrust of traffic, causes creep between the two adjacent lanes, and differential movement occurs.
2. Situation in 1. may be aggravated by gravitational force at steep grade.

Severity: See Table 11.

Density: See Table 9.

Example: Severe joint creeping at frequent intervals.

Possible Remedial Measures: None.

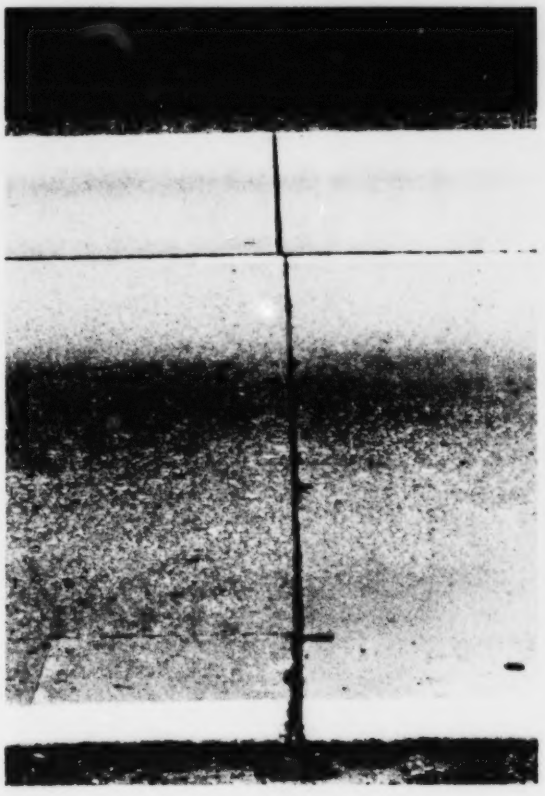


Figure 14. Moderate Joint Creeping

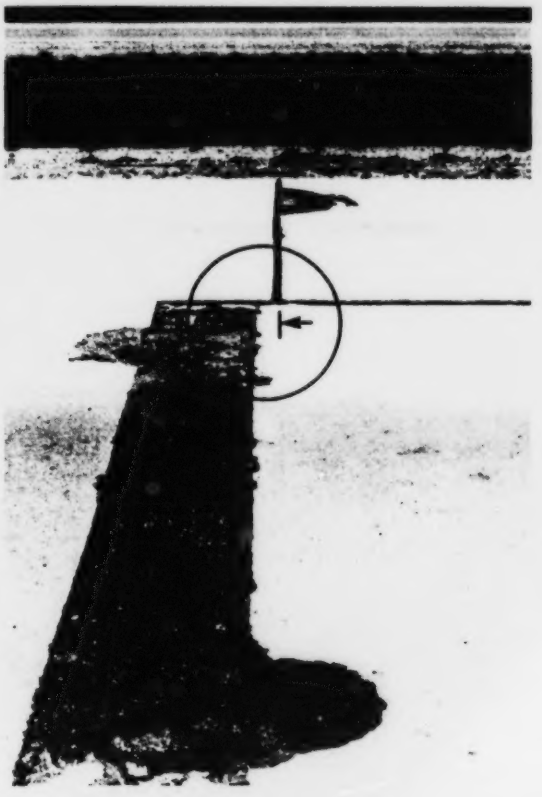


Figure 15. Severe Joint Creeping

Table 11. Guide for Describing Severity of Joint Deficiencies — Joint Creeping

Class	Uniform Description	Guidelines (Based on observation of appearance)
1	Very slight	Joints barely out of line
2	Slight	Noticeably out of line
3	Moderate	19 mm out of line
4	Severe	25 mm out of line
5	Very severe	50 mm out of line

Joint Sealant Loss

Description: Transverse or longitudinal joint sealant being squeezed or pulled out of the joint (Figures 15, 16, and 17).

Possible Causes:

1. Pulled out of an open joint by traffic action.
2. Expulsion of sealant due to compressive forces closing the joint too tightly.
3. Deterioration of sealant material.

Severity: See Table 12.

Density: See Table 9.

Example: Moderate loss of sealant occurs extensively throughout the section.

Possible Remedial Measures: Clean joint, fill with approved hot-pour joint sealant.

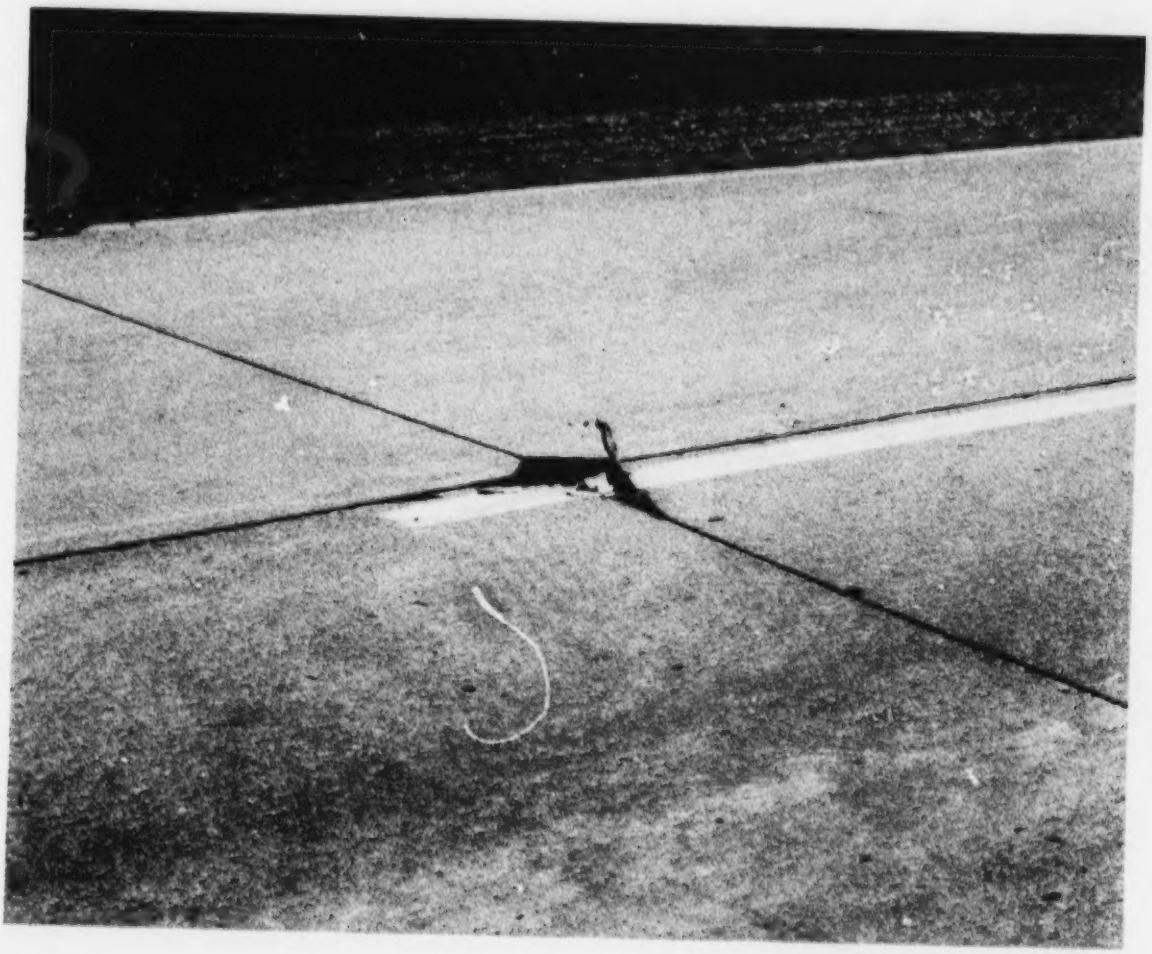


Figure 16. Slight Damage to Sealant

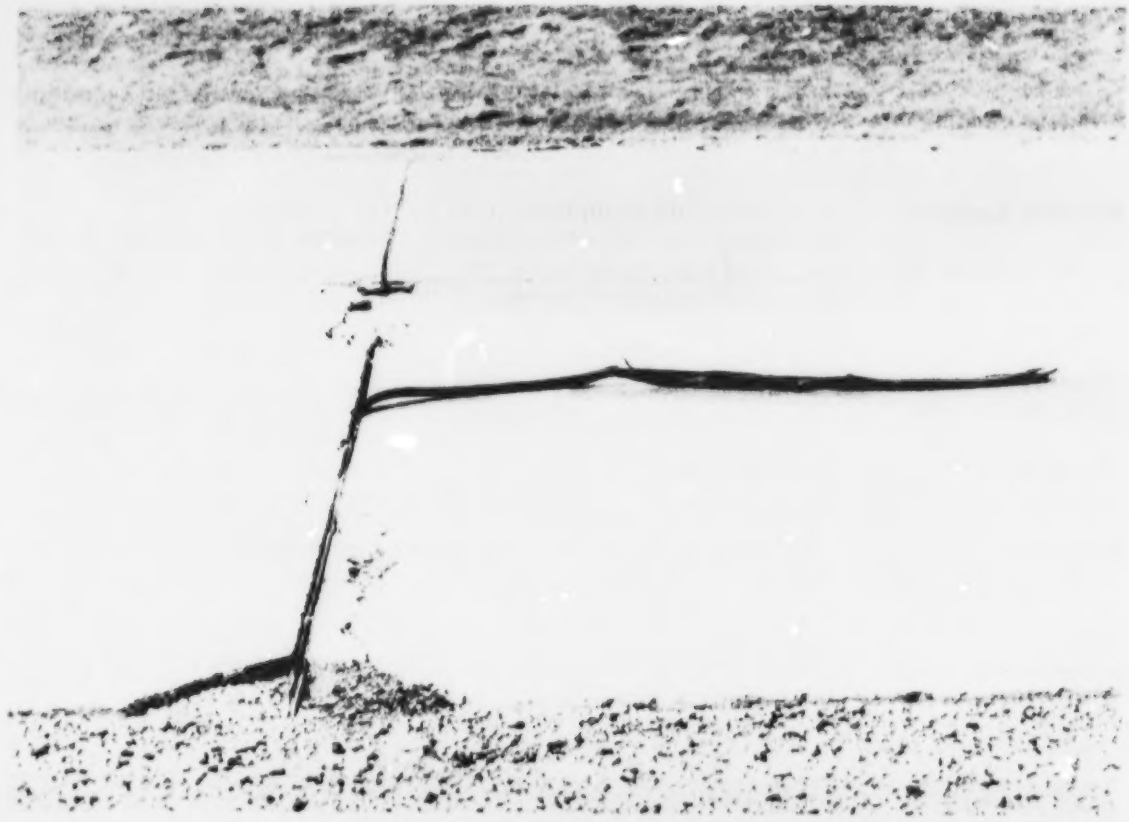


Figure 17. Severe Loss of Sealant

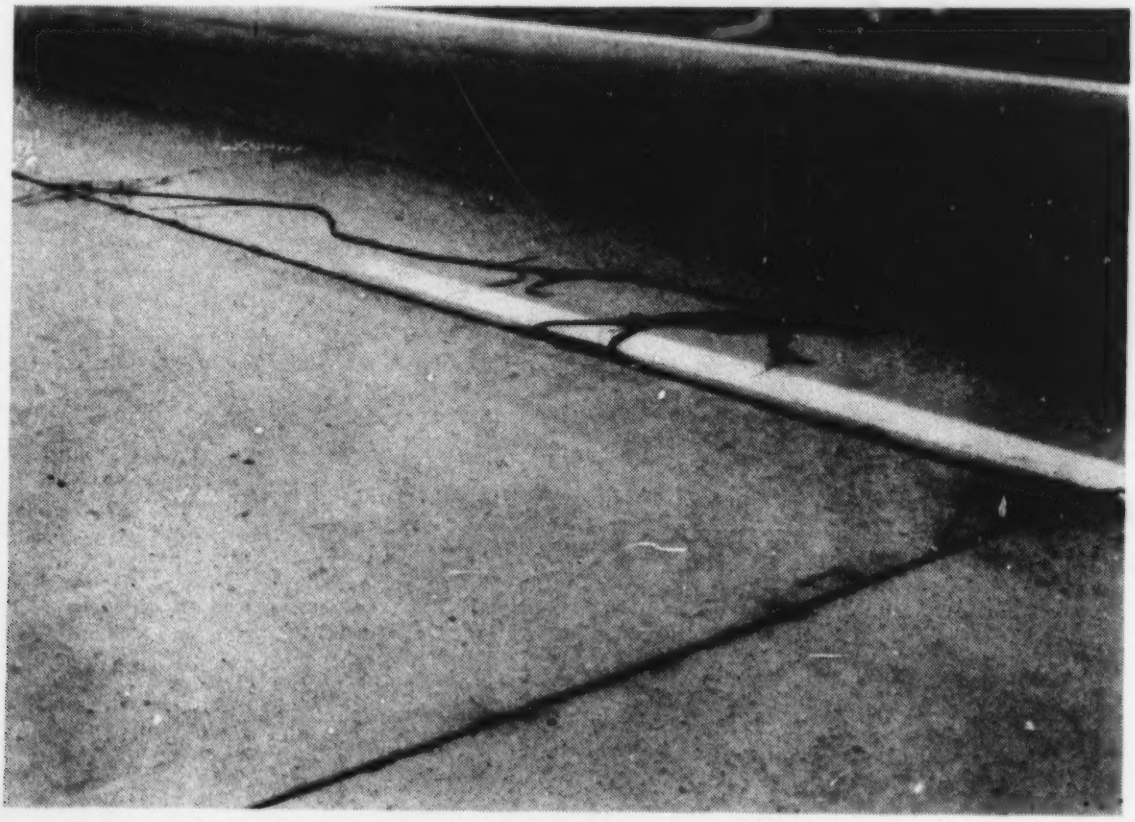


Figure 18. Moderate Loss of Sealant

Table 12. Guide for Describing Severity of Joint Deficiencies — Joint Sealant Loss

Class	Uniform Description	Guidelines (Based on observation of appearance)
1	Very slight	Barely pop-out or breaking.
2	Slight	Sealant broken and begins to pull out (up to 30 cm).
3	Moderate	Sealant broken and pulled out up to 50% of its length.
4	Severe	Sealant broken and pulled out up to 80% of its length.
5	Very severe	Sealant completely broken and pulled out more than 80% of its length. Ineffective as a sealant.

Joint Failures

Description: Excessive breakdown of slab adjacent to joint such that patching is required to maintain or restore ridability (Figures 19, 20, and 21).

Possible Causes:

1. High deflections of slab edges at joints under dynamic loads initiates spalls which progress into secondary spalls and then into joint failure. High deflections result from poor slab support and from loss of material supporting the slab by pumping.
2. High compressive stresses resulting from creeping slabs, restrained joints and frozen dowels can result in pavement blow-up or shattering of the concrete near the joint.
3. Combination of 1. and 2.

Severity: All are severe or very severe because it presents a very distressing visual effect, very rough ride and is inherently dangerous to the travelling public.

Density: See Table 9.

Example: Severe joint failures (or blow-ups) occur at few locations throughout the section.

Possible Remedial Measures: Removal of failed area, full-depth or partial-depth, and replacement with fresh concrete slab or asphalt concrete patch. Precast concrete slabs have been used.

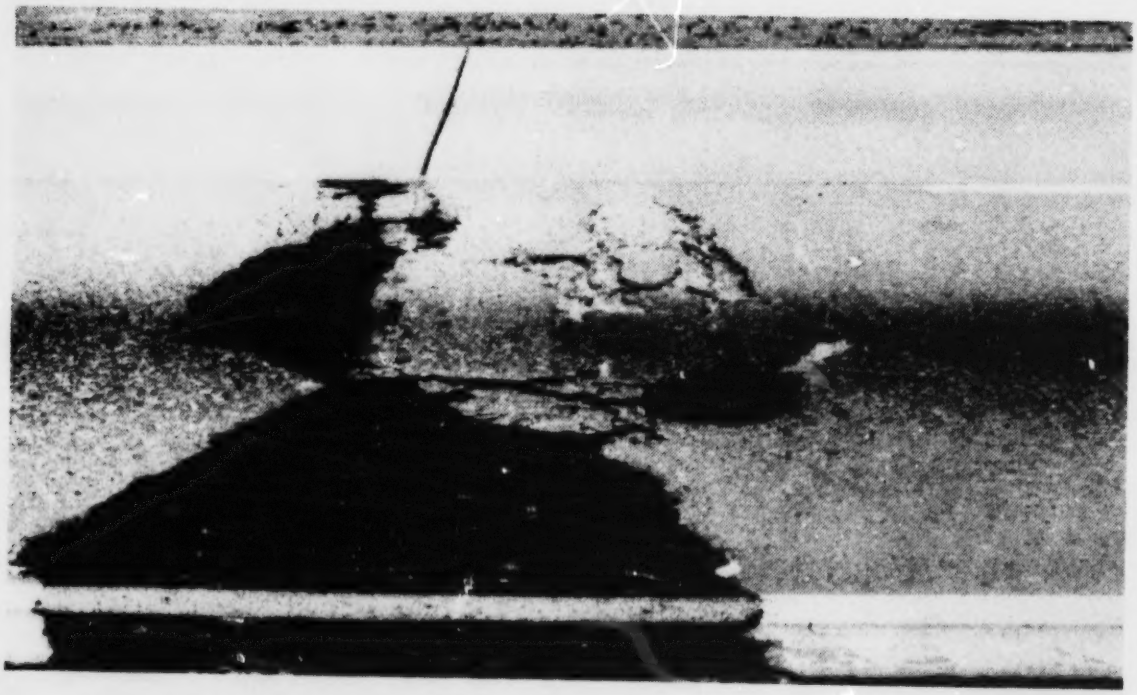


Figure 19. Failure from Joint Spalling and Loss of Base Support

Figure 20. Failure from Insufficient Bearing Support

Figure 21. Blow-Up Failure from Compressive Stresses

Distress Manifestations

5.4 Cracking

Longitudinal Crack 30
Meandering Crack 33
Corner Crack 35
'D' Crack 38
Transverse Crack 40
Diagonal Crack 44
Edge Crescent Crack 45
Miscellaneous Crackings 47

5.4 Cracking

Longitudinal Crack

Description: Cracks which follow a course approximately parallel to the centre line of the pavement and are generally quite straight (Figures 22 and 23).

Possible Causes:

1. Lateral contraction, bending or curling.
2. Fill settlement downwards and/or outward.
3. Insufficient bearing support.
4. Poor construction paving procedure.

Severity: See Table 13.

Density: See Table 14.

Example: Slight longitudinal cracks occur frequently over the section.

Possible Remedial Measures: Clean crack of debris and seal with asphalt if crack is moderate. If crack is spalled and broken with loose-pieces, repairs might consist of sawing and removing the slab, partial or full depth, and filling with rapid-setting concrete mix or hot-mix asphalt.

Figure 22. Longitudinal Cracking (Note Crack's Straightness)

Figure 23. Slight Crack (10 mm Wide)

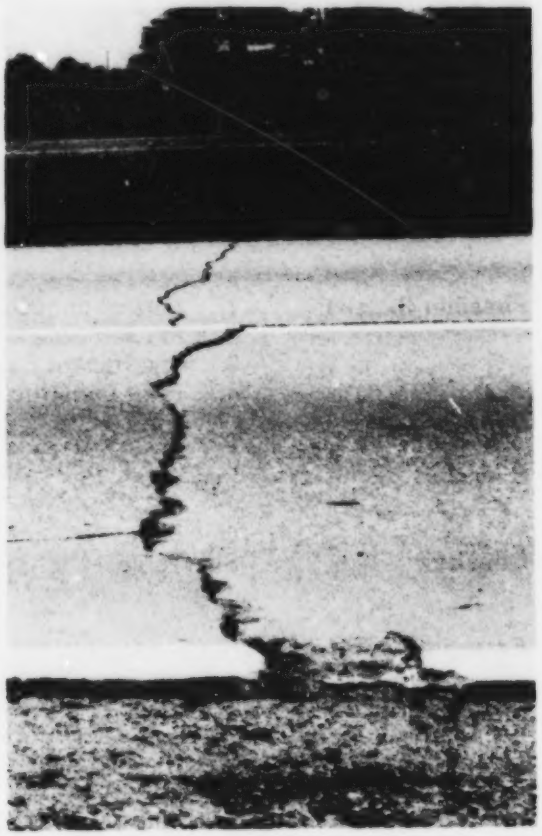


Figure 24. Very Severe Crack (Edge Spalled 13 mm, Faulting, Debris in between)

Table 13. Guide for Describing Severity of Pavement Cracking

Class	Uniform Description	Guidelines (Based on crack width and its condition)	Figure
1	Very slight	3 mm	
2	Slight	3 mm - 13 mm	23
3	Moderate	13 mm - 19 mm	
4	Severe	19 mm - 25 mm (with spalling and faulting developed)	
5	Very severe	>25 mm (with spalling and faulting developed)	24

Table 14. Guide for Describing Density of Pavement Cracking — Longitudinal Cracks

Class	Uniform Description	Guidelines (Based on percent of total length in the pavement section affected by defect)
1	Few	10%
2	Intermittent	10 - 20%
3	Frequent	20 - 50%
4	Extensive	50 - 80%
5	Throughout	80 - 100%

Meandering Crack

Description: Cracks which wander like a serpent across the traffic lane (Figures 25 and 26) and generally occur at a transverse joint.

Possible Causes:

1. Expansion and contraction of the concrete due to thermal changes with poorly performing transverse joints.
2. Pumping through an adjacent transverse joint which created a void and subsequent traffic loading induces failure.
3. Lack of bearing support due to subgrade mass movement.
4. Improper construction procedures such as late sawing of joints.

Severity: See Table 13.

Density: See Table 14.

Example: Moderate meandering cracks at frequent intervals.

Possible Remedial Measures: Clean crack of debris and seal or patch with asphaltic materials.

Figure 25. Meandering Crack (Severe)

Figure 26. Meandering Crack (Moderate)

Corner Crack

Description: Diagonal cracks forming a triangle with a longitudinal edge or joint, and a transverse joint or crack. The size of the triangle so formed is generally about 30 cm and, with few exceptions, no larger than 60 cm (Figures 27, 28 and 29).

Possible Causes:
1. Insufficient bearing support.
2. Excessive compressive stresses.

Severity: See Table 13.

Density: See Table 15.

Example: Slight corner cracks occur at frequent intervals.

Possible Remedial Measures: Clean crack of debris or broken pieces and seal or patch with asphaltic materials.

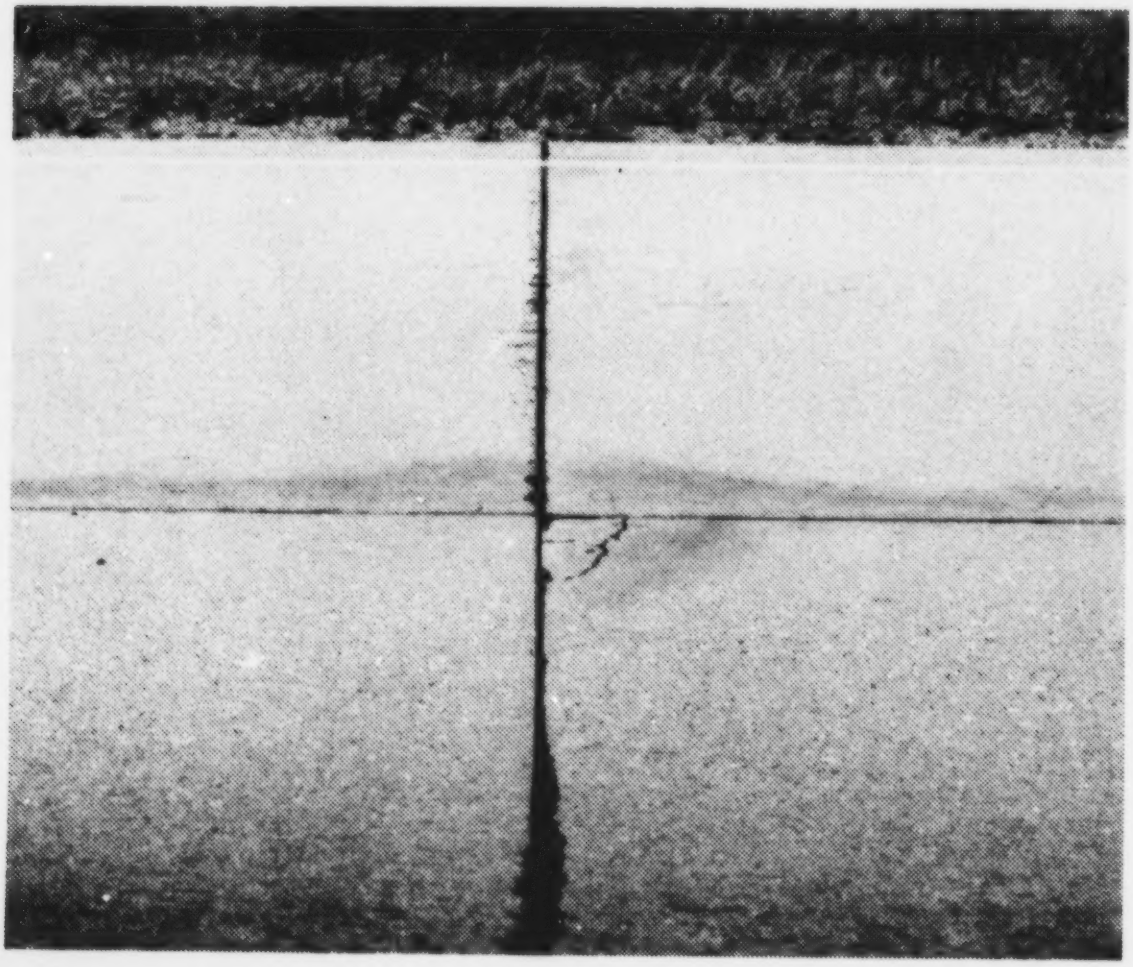


Figure 27. Corner Crack (Slight) at Longitudinal Joint

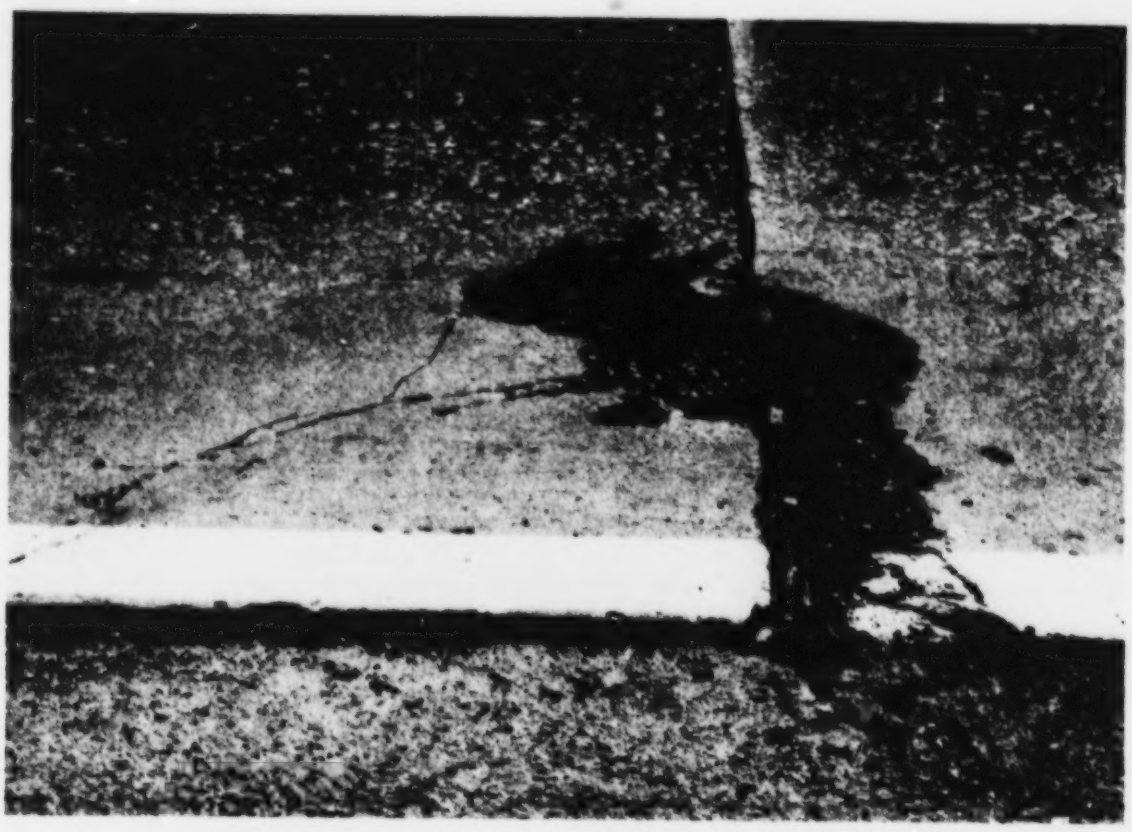


Figure 28. Severe Corner Crack at Transverse Joint

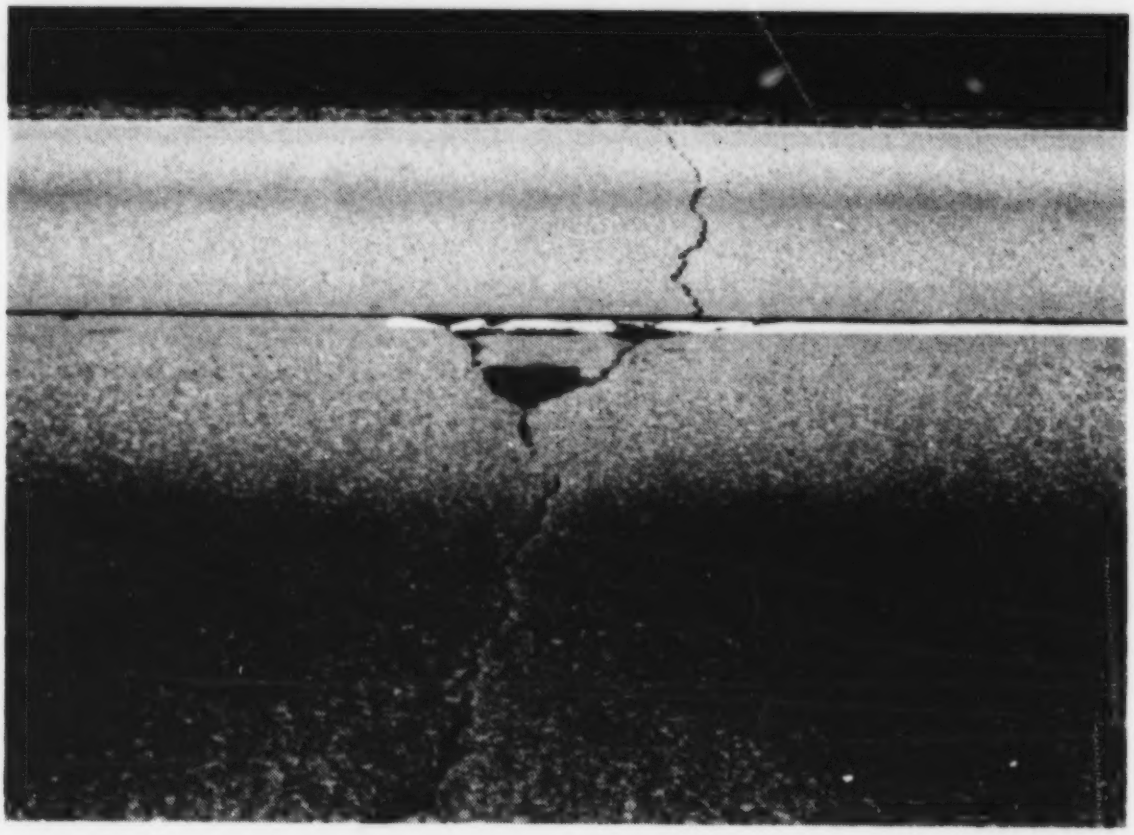


Figure 29. Severe Corner Crack at Transverse Crack

Table 15. Guide for Describing Density of Pavement Corner Cracking

Class	Uniform Description	Guidelines (Based on percent of total pavement surface area in the pavement section affected by defect)
1	Few	<10%
2	Intermittent	10 - 20%
3	Frequent	20 - 50%
4	Extensive	50 - 80%
5	Throughout	80 - 100%

'D' Crack

Description: A series of closely-spaced, fine, crescent-shaped cracks in the concrete surface usually paralleling a joint or major crack and usually curving across slab corners (Figures 30, 31, and 32). This cracking is very similar in appearance to corner cracks. However, a distinctive feature differentiating these two is that for 'D' cracks the crescent is concave in relation to the slab corners or joints while corner crack's crescent is convex to the slab corners or pavement edge.

Possible Causes: Distress is initiated through freeze-thaw activity in critically-saturated coarse aggregate particles located in the lower level of pavement slabs.

Severity: See Table 13.

Density: See Table 15.

Example: Moderate 'D' cracks occur at frequent intervals.

Possible Remedial Measures: Clean cracks of debris or broken pieces and seal or patch with asphaltic materials.

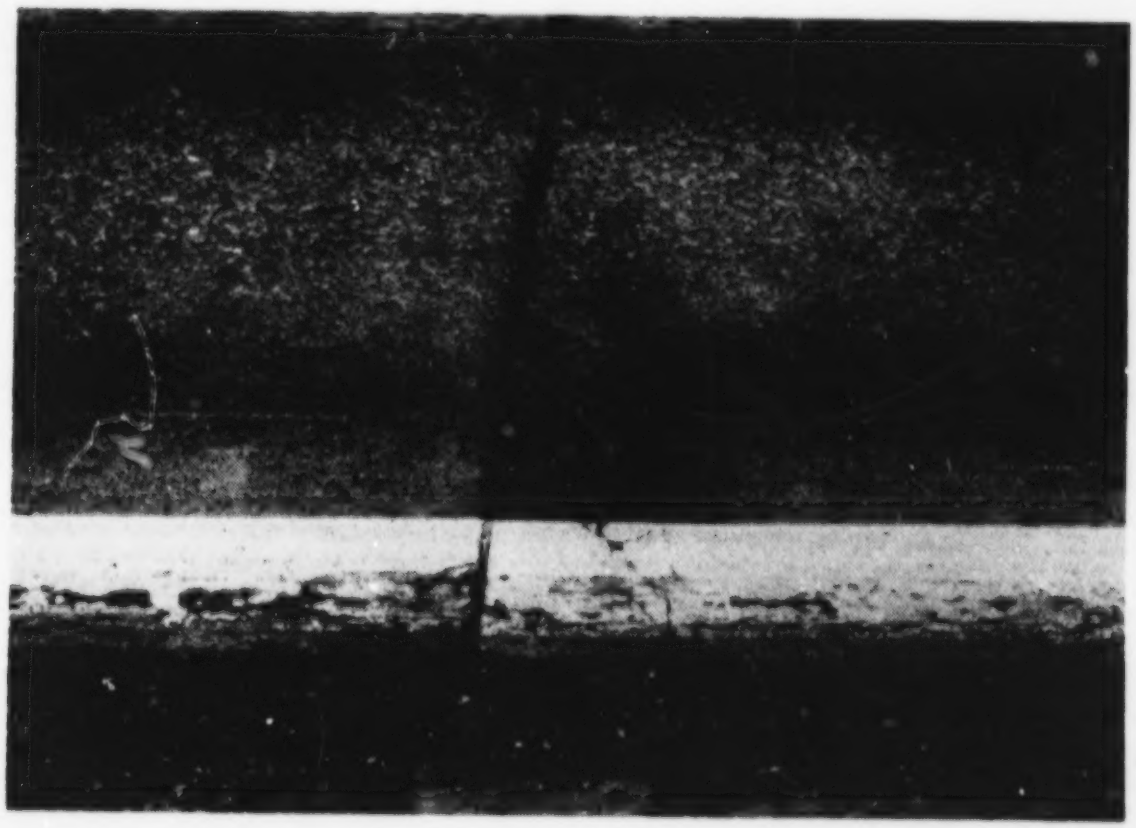


Figure 30. Slight 'D' Crack

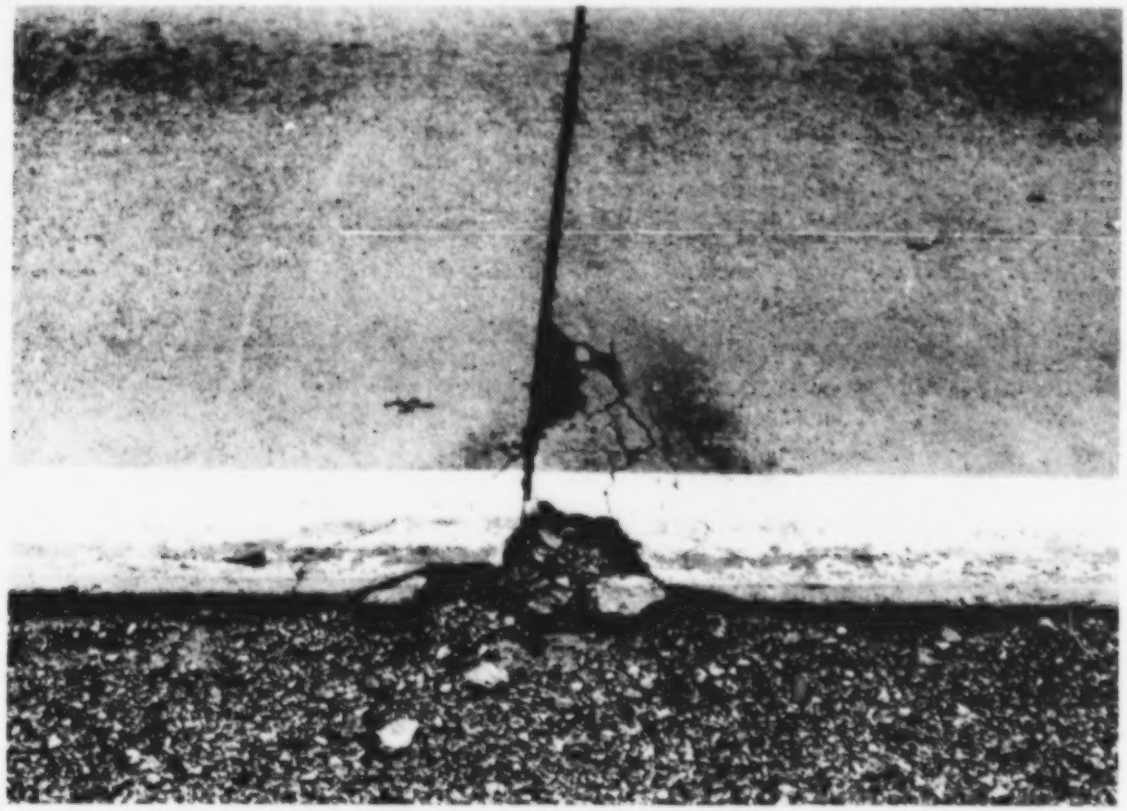


Figure 31. Moderate 'D' Crack

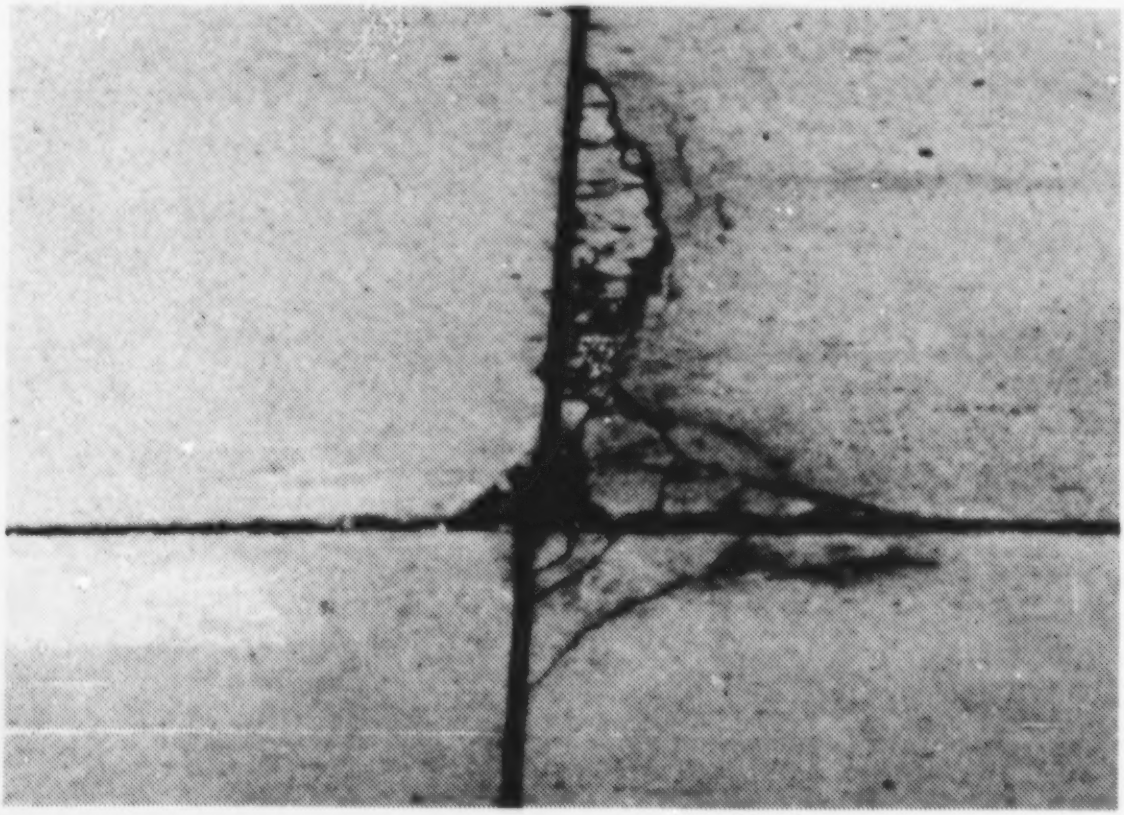


Figure 32. Severe 'D' Crack

Transverse Crack

Description: Crack which follows a course approximately at right angles to the pavement centre line (Figures 33 and 34).

Possible Causes:

1. Thermal expansion or contraction.
2. Overlong joint spacing.
3. Insufficient bearing support.
4. Swelling or shrinkage of subsoils.
5. Poor aggregates in concrete mix.
6. Poor joint performance due to improper construction.

Severity: See Table 16. Transverse cracks should be further subdivided into single or multiple and spacing between cracks (Figure 35).

Density: See Table 15 (Guide of Corner Crack).

Example: Moderate multiple transverse cracks occur throughout the section spaced approximately at 2-m intervals.

Possible Remedial Measures: Clean crack of debris or route and seal or patch with asphaltic materials.

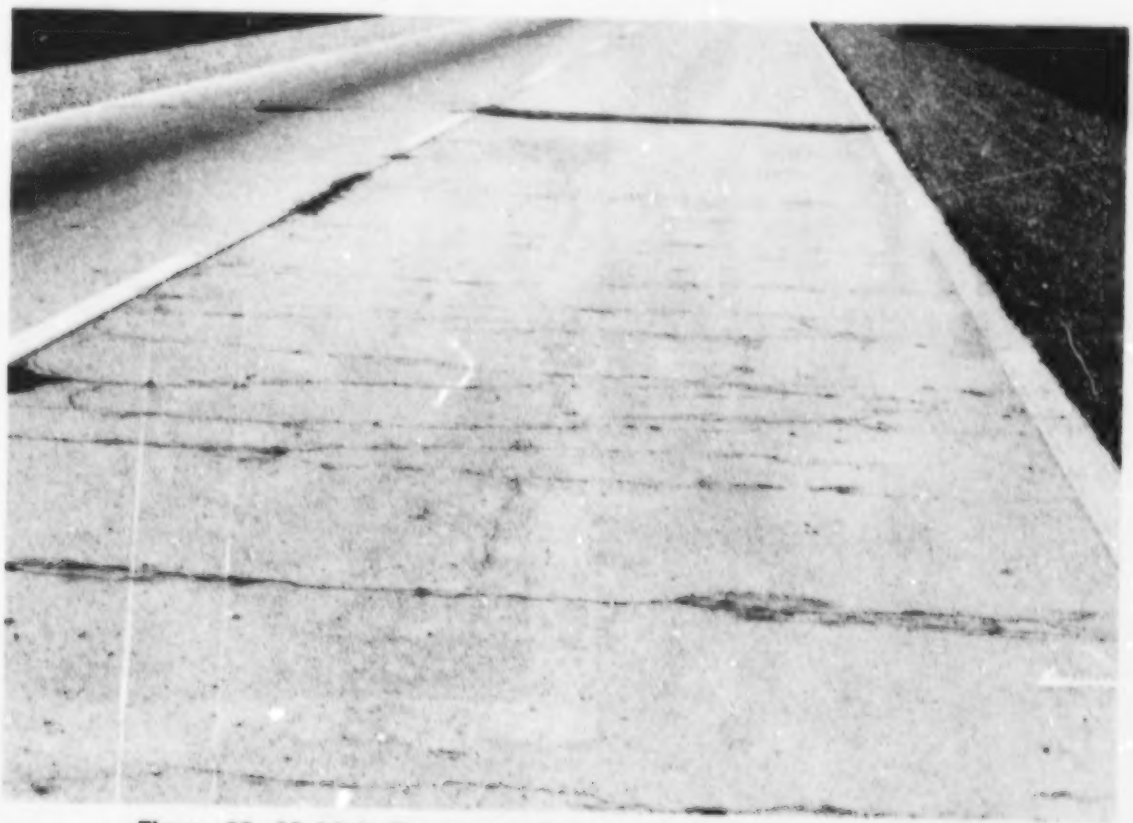


Figure 33. Multiple Transverse Cracks Between Joints of Pavement (a Dowelled, Reinforced Slab)

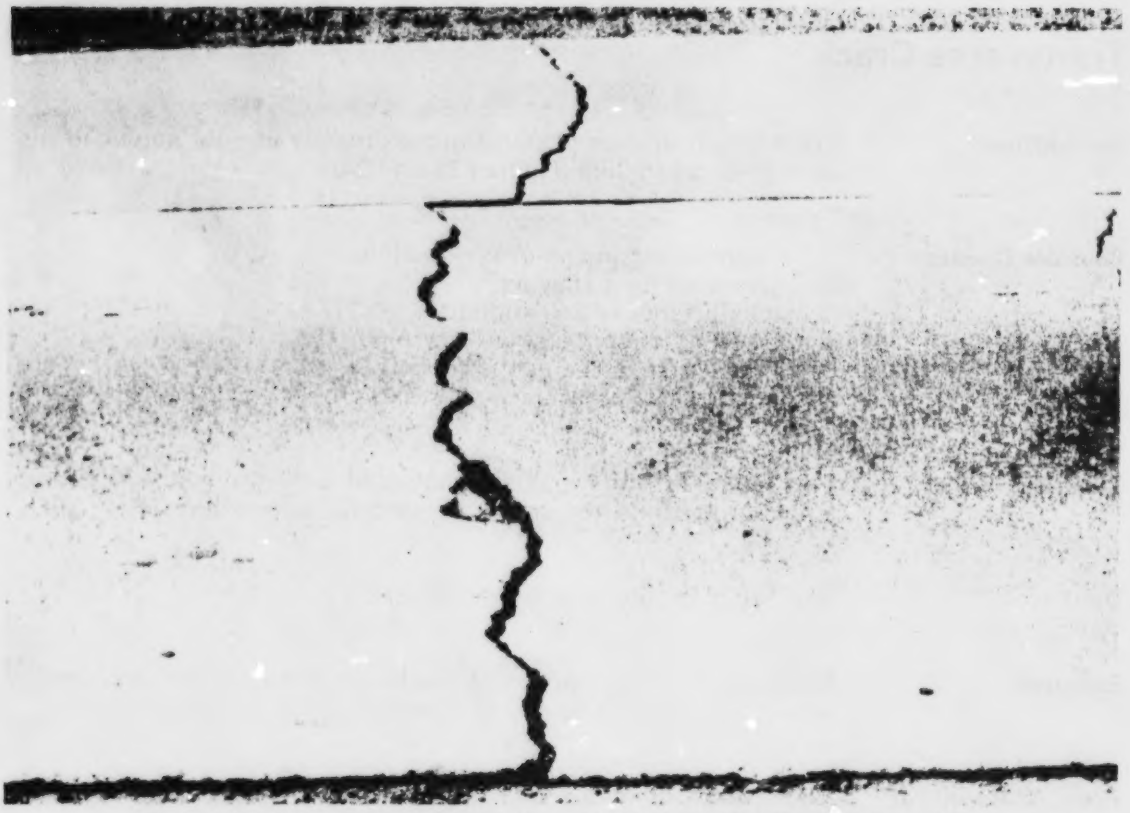


Figure 34. Very Severe Transverse Crack with Spalling and Faulting Infiltrated with Debris

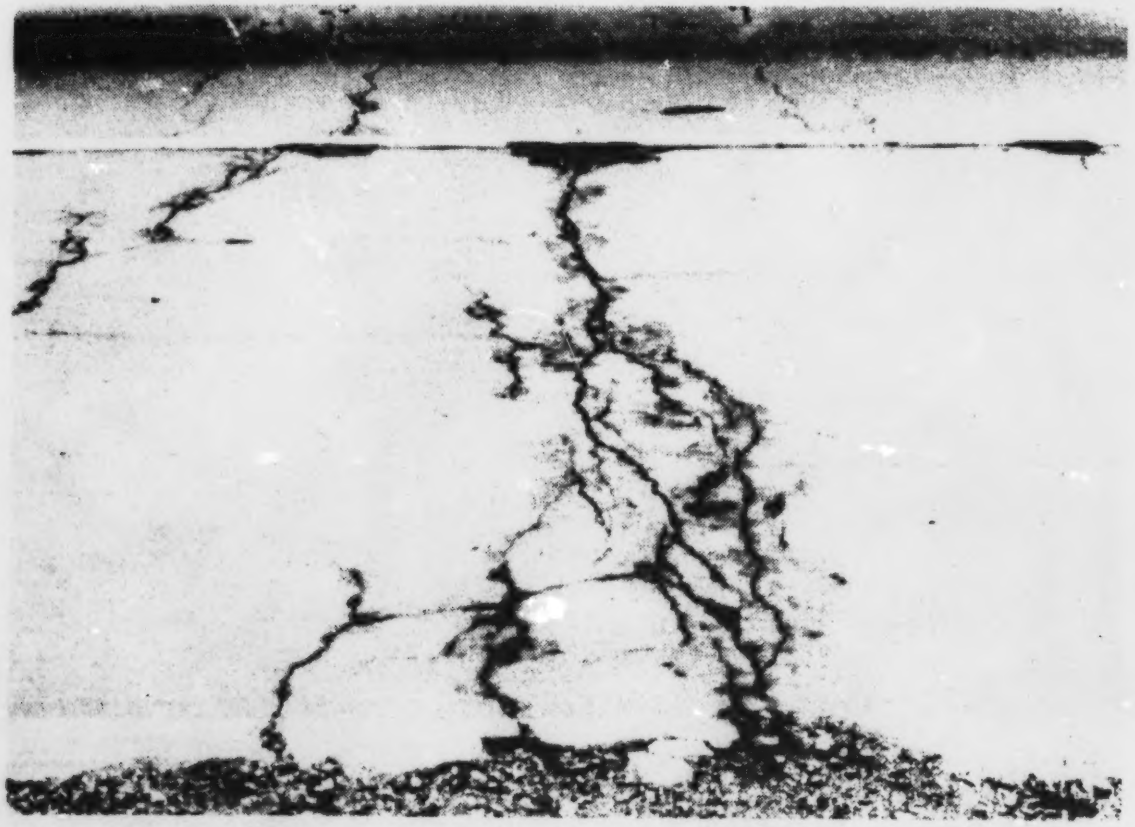


Figure 35. Multiple Transverse Cracks, Moderate to Severe

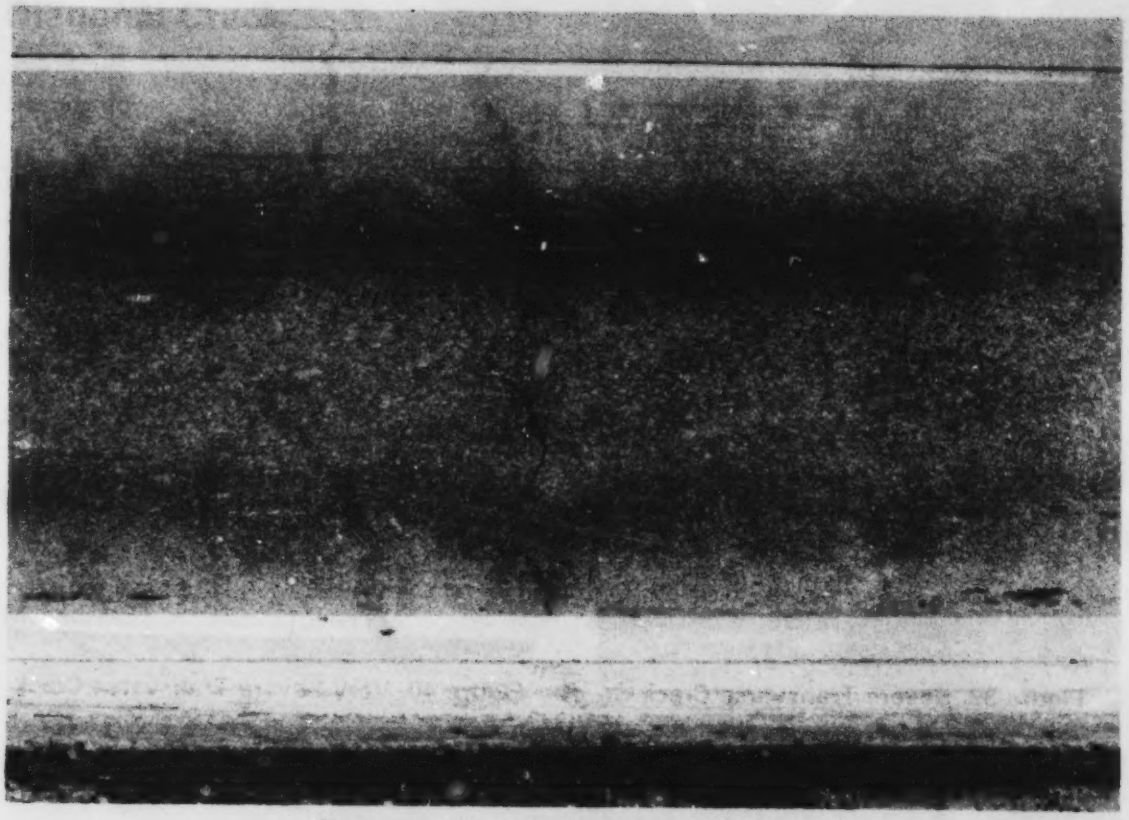


Figure 36. Very Slight Transverse Crack

Figure 37. Slight Transverse Crack

Figure 38. Moderate Transverse Crack

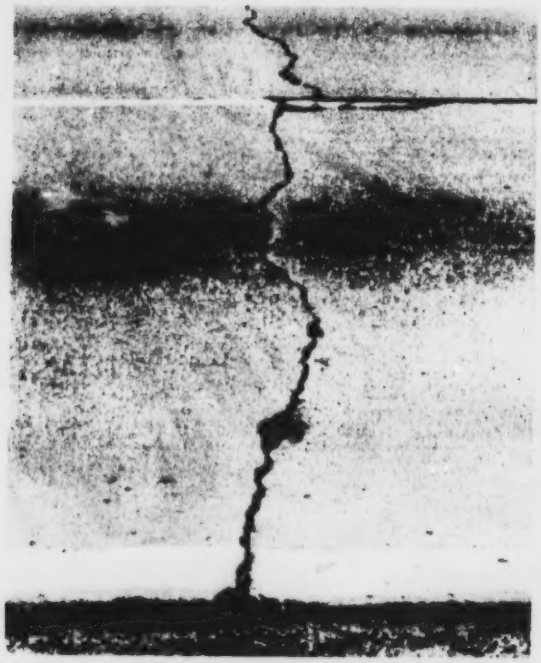


Figure 39. Severe Transverse Crack

Figure 40. Very Severe Transverse Crack

Table 16. Guide for Describing Severity of Pavement Transverse Cracking

Class	Uniform Description	Guidelines* (Based on crack width, condition and multiplicity)	Figure
1	Very slight	3 mm (partial and singular).	36
2	Slight	3 mm - 13 mm (full and singular with very slight spalling or faulting).	37
3	Moderate	13 mm - 19 mm (singular or multiple with slight spalling and faulting).	38
4	Severe	19 mm - 25 mm (with spalling, faulting in singular or multiple cracks).	39
5	Very severe	>25 mm (with spalling, faulting, and debris trapped in between in singular or multiple cracks).	40

* In describing the severity of transverse cracking, the characteristics of the transverse cracks must also be described in terms of spacing between cracks. Actual distance estimated to the nearest metre should be used, for example, "very slight transverse cracks spaced 3 m apart."

Diagonal Crack

Description: Crack which follows a course approximately diagonal to the centre line (Figure 41).

Possible Causes:
1. Concrete shrinkage.
2. Lack of bearing support.

Severity: See Table 13.

Density: See Table 15.

Example: Moderate diagonal cracks occur at few locations in the section.

Possible Remedial Measures: Clean crack of debris or route and seal or patch with asphaltic materials.

Figure 41. Diagonal Crack

Edge Crescent Crack

Description: Arc crack extending from transverse joint or transverse crack to the pavement edge generally 0.5 m to 1 m inward from pavement edge and covering an area of 5 m to 6 m from end to end (Figures 42 and 43).

Possible Causes:
1. Poor transverse joint performance.
2. Lack of bearing support due to pumping action of pavement slab.

Severity: See Table 13.

Density: See Table 15.

Example: Slight crescent crack at few intervals.

Possible Remedial Measures: Clean crack of debris and seal or patch with asphaltic materials.

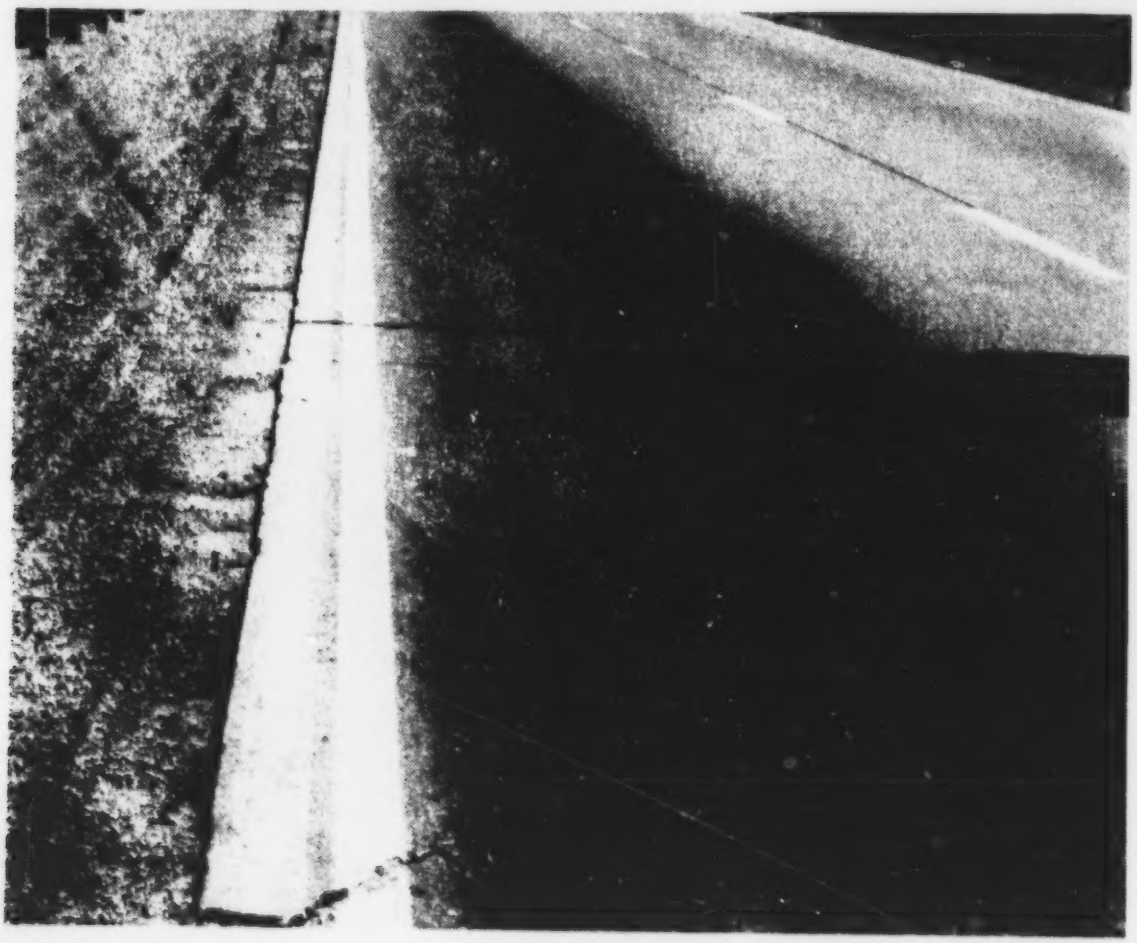


Figure 42. Edge Crescent Crack

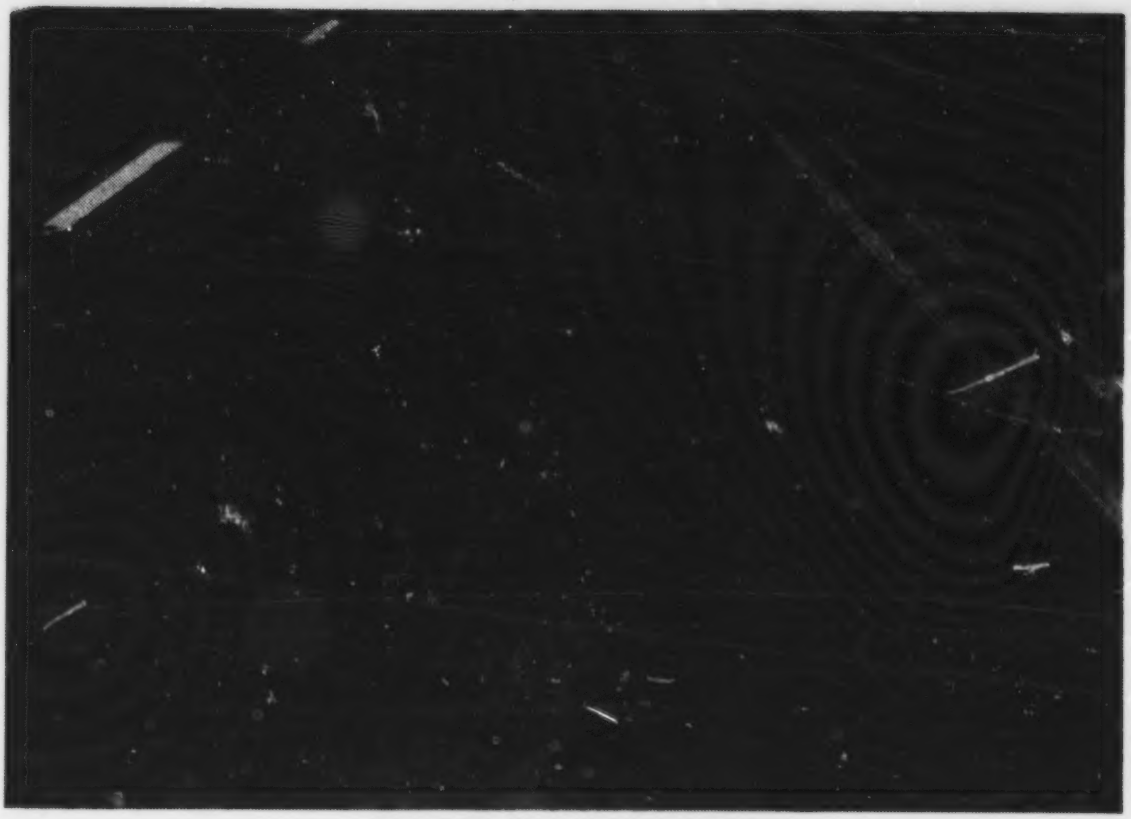


Figure 43. Edge Crescent Crack

Miscellaneous Crackings

Reflection Crack

Description: Crack which reflects through the hot-mix asphalt patching or resurfacing (Figure 44).

Possible Causes: Stresses which caused the original failure overstressing the new surface at the same location.

Severity: See Table 13.

Density: See Table 15.

Example: Severe reflection cracks of transverse formation occur at frequent intervals throughout the resurfaced area.

Possible Remedial Measures: Clean crack of debris and seal or patch with asphaltic materials.

Others

There are other cracks which are not specifically described in the above subsections because they are either uncommon or are restricted to local areas. In all cases of reporting such cracks, the crack should be named or described briefly and estimates given of its severity (Table 13) and density of occurrence (Table 15.)

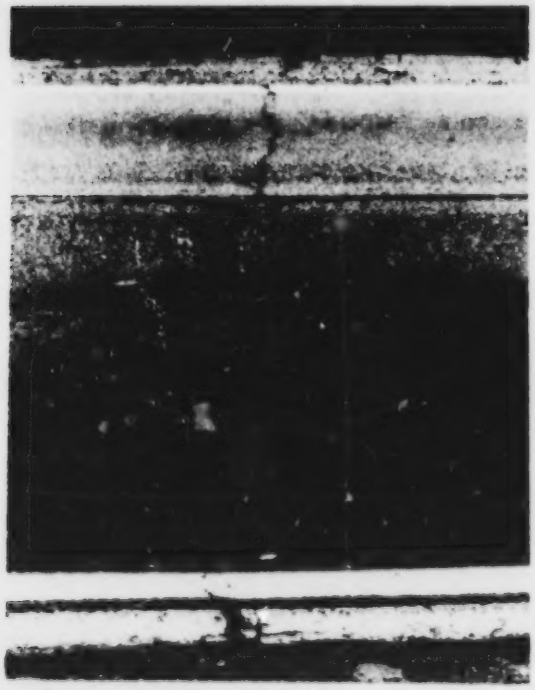


Figure 44. Reflection Crack (Transverse)

Figure 45. Hair-Line Parallel Cracks (Longitudinal)

Figure 46. Hair-Line Craze Cracks

Distress Manifestations

5.5 Spalling

Joint Spalling 49
Crack Spalling 52

5.5 Spalling

Joint Spalling

Description: The breaking or chipping of the pavement at joints usually resulting in fragments with feathered edges (Figures 47 and 48).

Possible Causes: Spalling of concrete edges is generally due to excessive pressure locally, resulting from combination of traffic, expansion, warping, and curbing; spalling is progressive.

1. Expansive internal pressure due tc corrosion of rebar or dowels.
2. Infiltration of debris preventing movement of slabs due to thermal expansion creating excessive compressive stresses.
3. Seized dowel bars combined with thermal expansion.
4. Misalignment of dowel bars and base movement.

Severity: See Table 17 and Figures 49, 50, 51, 52 and 53.

Density: See Table 9.

Example: Severe joint spalling (transverse) occurs extensively throughout the section.

Possible Remedial Measures: Clean joint of debris; patch over with cold-mix or hot-mix asphalt. For more permanent result, saw cut and patched with hot-mix is recommended.

Figure 47. Transverse Joint Spalling

Figure 48. Longitudinal Joint Spalling

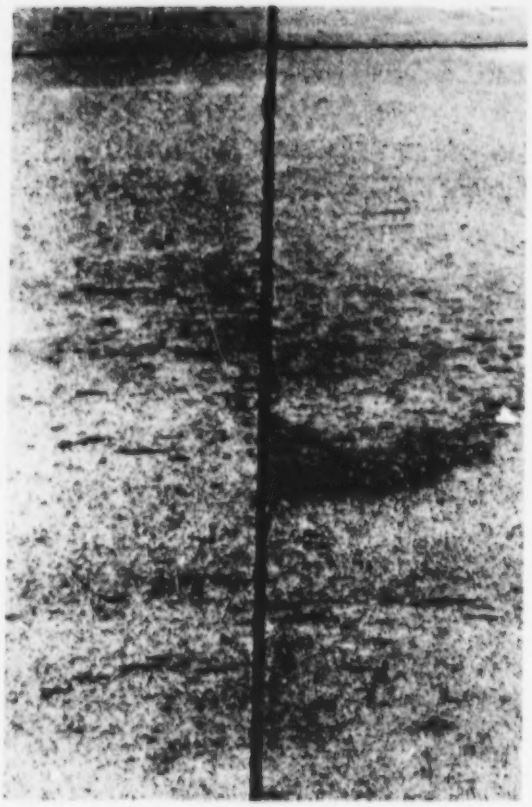


Figure 49. Very Slight Joint Spalling

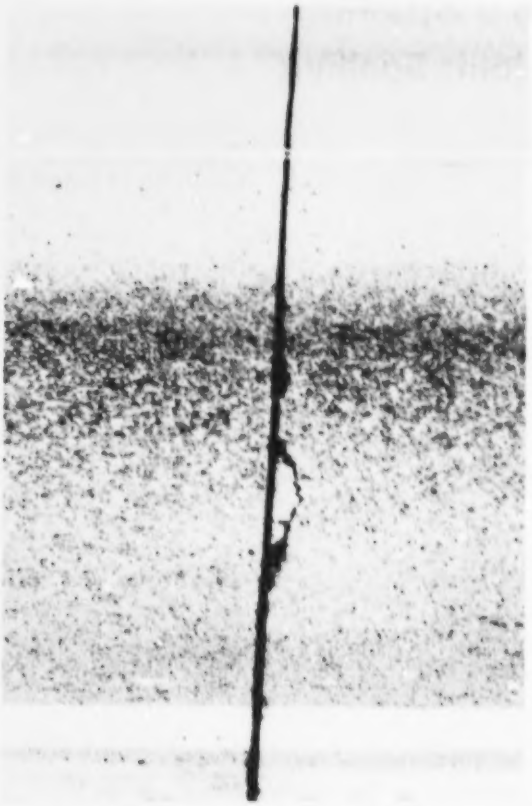


Figure 50. Slight Joint Spalling

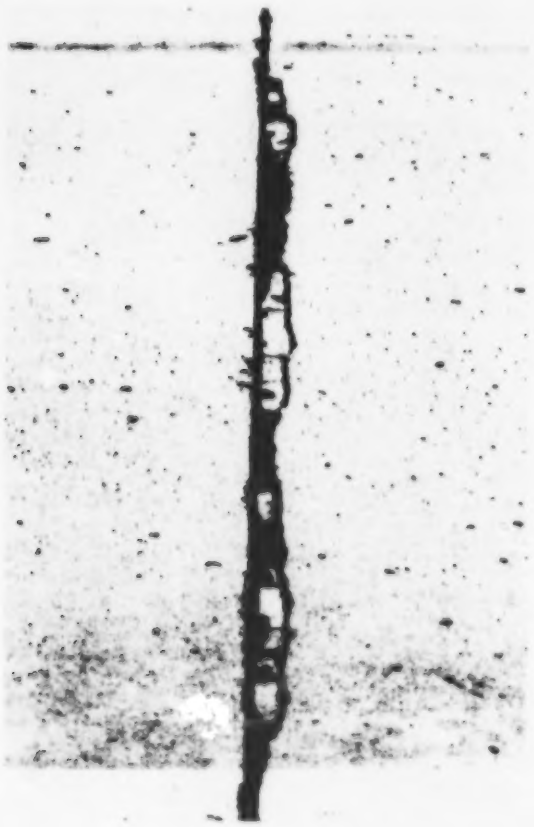


Figure 51. Moderate Joint Spalling

Figure 52. Severe Joint Spalling

Figure 53. Very Severe Joint Spalling

Table 17. Guide for Describing Severity of Joint Spalling

Class	Uniform Description	Guidelines (Based on width, length and depth of spalling)	Figure
1	Very slight	Small crack(s) with very small fractures.	49
2	Slight	Small crack(s) with small pieces broken or disappeared.	50
3	Moderate	Cracked with fractures but no actual large missing pieces.	51
4	Severe	Large pieces actually missing and at wheel paths.	52
5	Very severe	Large pieces actually missing across joint.	53

Crack Spalling

Description: The chipping or breaking away of fragments along the crack edges usually resulting in pot-holes (Figures 54 and 55).

Possible Causes: Spalling of concrete edge is generally due to excessive pressure locally, resulting from combination of traffic forces and expansion. Spalling is progressive.

1. Expansive internal pressure which causes the original cracks.
2. Infiltration of debris into the crack preventing movement of slab due to thermal expansion creating excessive compressive stresses.
3. Combined traffic action.

Severity: See Table 18.

Density: See Table 9.

Example: Severe spalling of transverse cracks occurs extensively throughout the section.

Possible Remedial Measures: Clean crack of debris; patch over with cold-mix or hot-mix. For more permanent result, saw cut and patched with hot-mix is recommended.

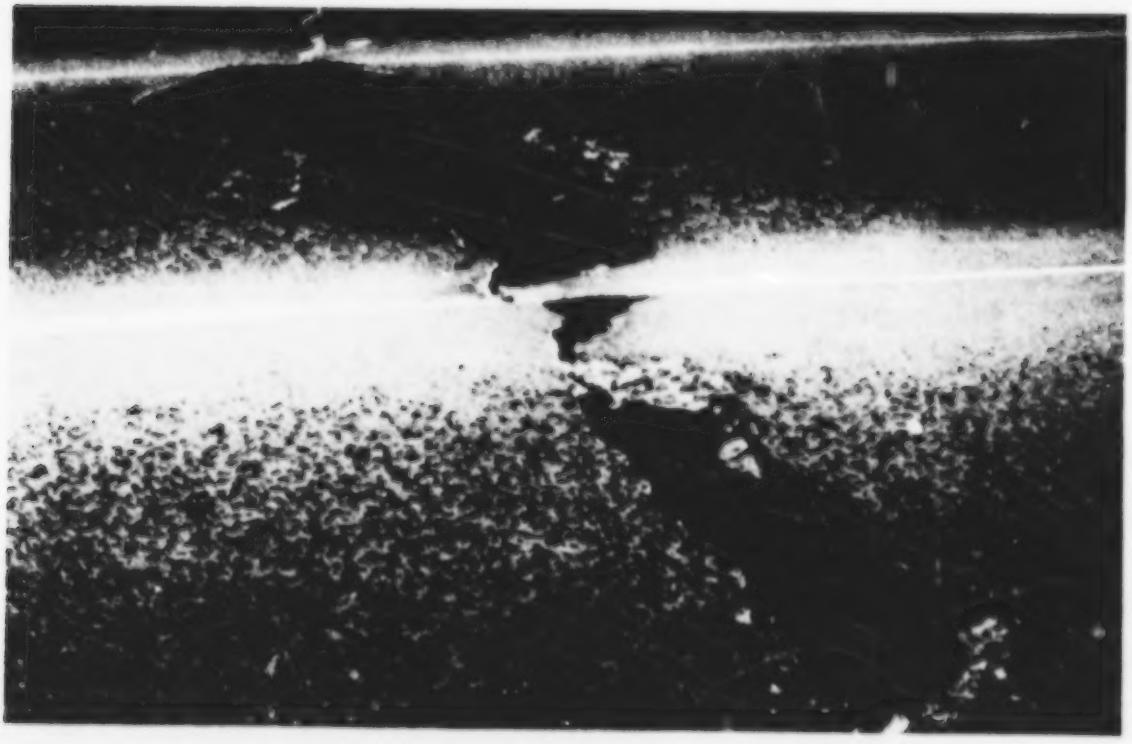


Figure 54. Transverse Crack with Very Severe Spalling

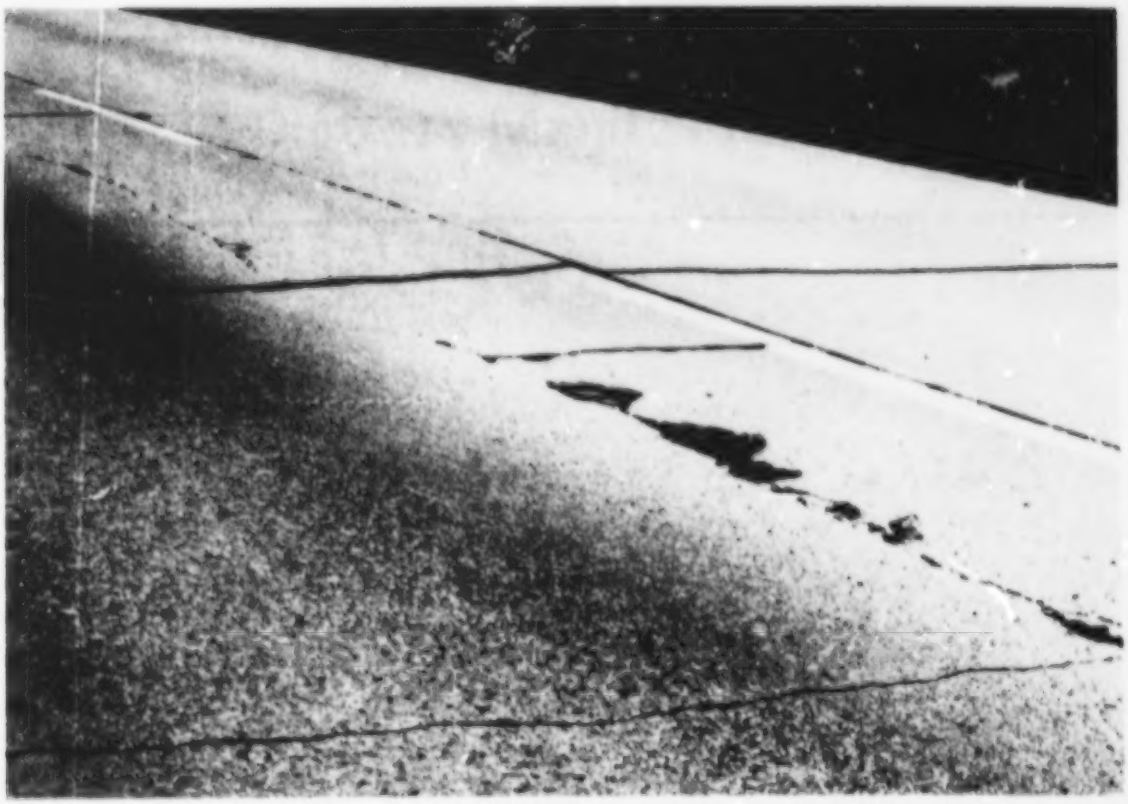


Figure 55. Longitudinal Cracking with Severe Spalling

Table 18. Guide for Describing Severity of Crack Spalling

Class	Uniform Description	Guidelines (Based on appearance of spalling)
1	Very slight	Small crack(s) with very small fracture close to existing crack with fractures in the spalled area.
2	Slight	Small crack(s) with few small pieces missing from the fractured area.
3	Moderate	Many small pieces missing from fractured area.
4	Severe	Large pieces missing from the fractured area.
5	Very severe	Large pot-holes form at places along the crack.

Distress Manifestations

5.6 Miscellaneous Distresses

Lane Separation 54
Permanent Slab Warping 54
Wheel-Track Wear 55

5.6 Miscellaneous Distresses

There are other distresses which are not specifically described in the above groups because they are either uncommon or are restricted to local areas and peculiar circumstances. In all cases of reporting such distress, the distress should be named or described briefly and estimates given of its severity and density of occurrence from the appropriate tables.

Lane Separation

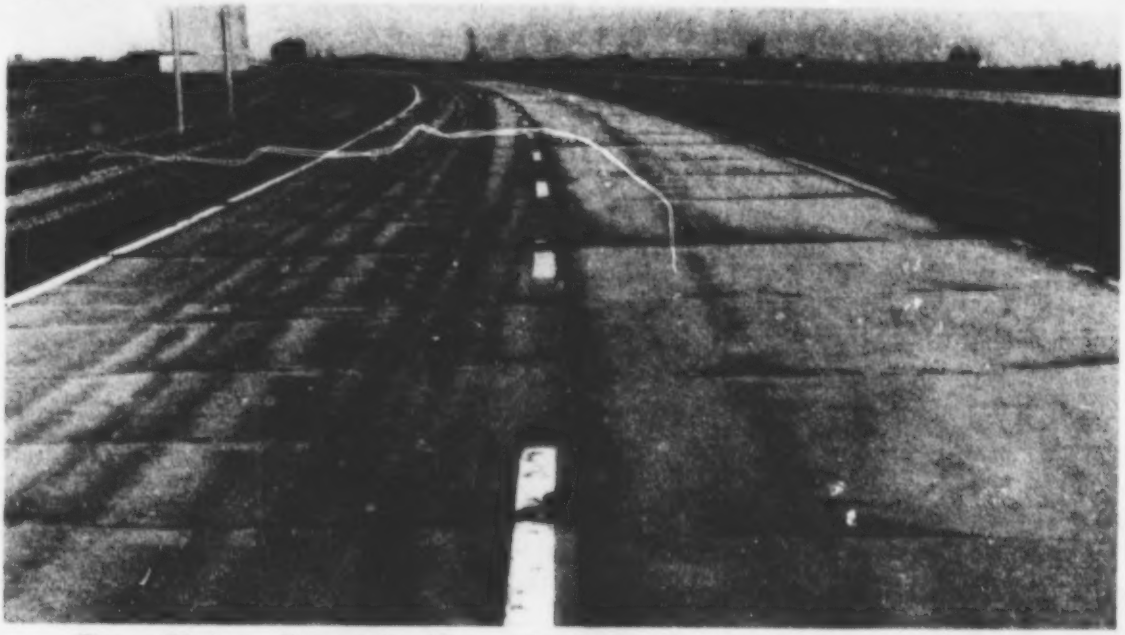


Figure 56. Lane Separation (Separation of the Two Adjacent Lanes along the Longitudinal Joint)

Permanent Slab Warping

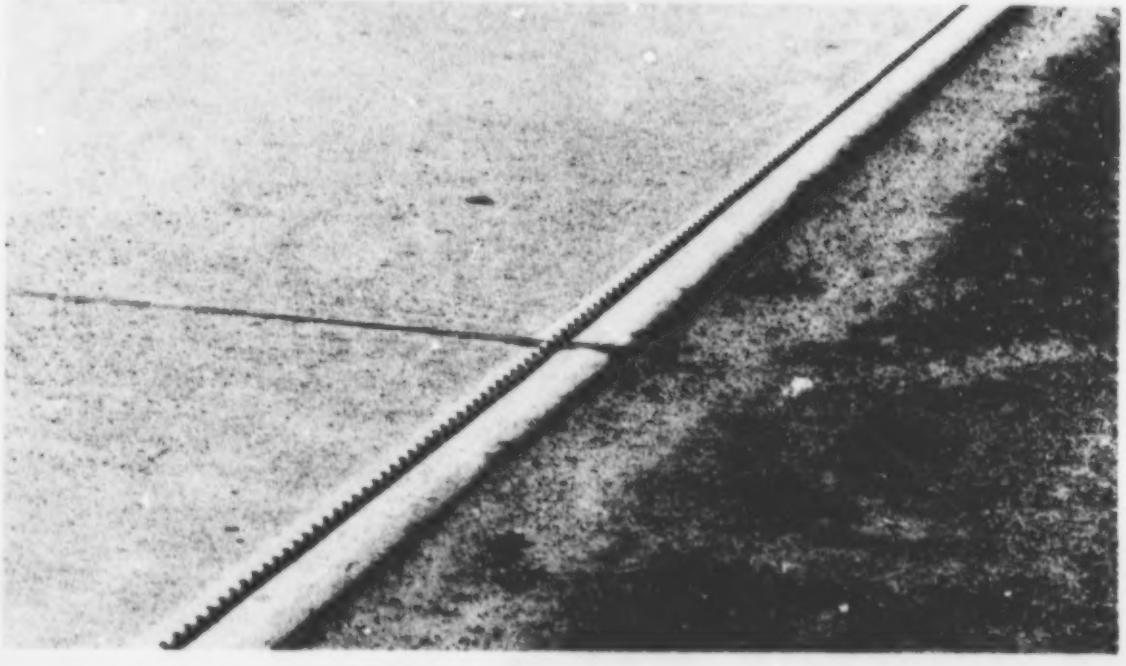


Figure 57. Slab Warping (Note Low Point at Transverse Joint)

Wheel-Track Wear

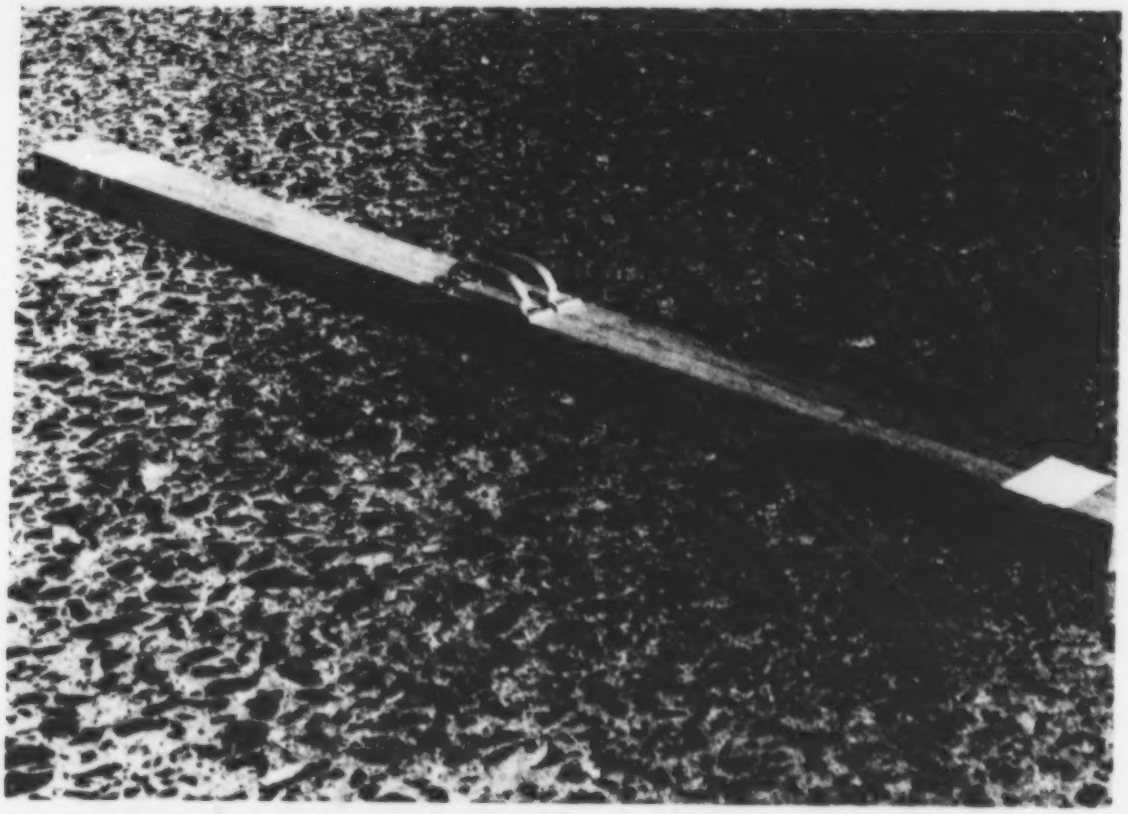


Figure 58. Wheel-Track Wear (Trough-Like Transverse Profile Is Result)

6. Maintenance

6. Maintenance

When pavement distress leads to a rough surface condition or to a locally-dangerous bump or hole, remedial measures must be taken to either:

- seal the joints and/or cracks to prevent water from getting down to the susceptible layers and, thereby, worsening the existing poor condition;
- smoothen the rough surface; or
- cure the causes of the bump or hole or faulting.

Figures 59, 60, 61, 62, 63 and 64 illustrate transverse joint repair, full-depth pressure relief-joint, precast slab, cold-mix patch and hot-mix patching. In reporting on the presence of maintenance, the density of occurrence should be estimated in the terms given in Table 19.

Example: Extensive full-width, hot-mix patching in the section.

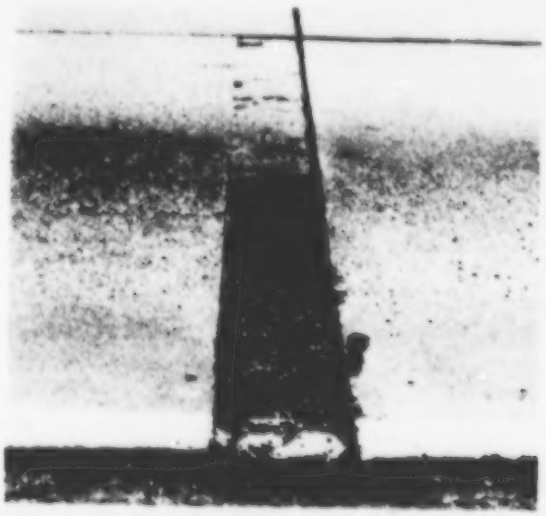


Figure 59. Repaired Joint in Poor Condition

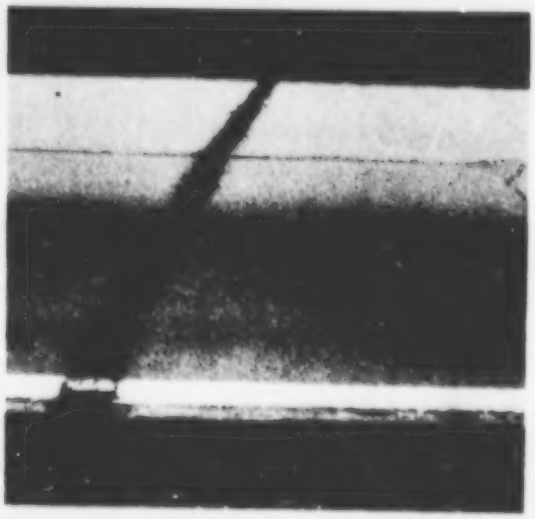


Figure 60. Full-Depth Pressure Relief Joint

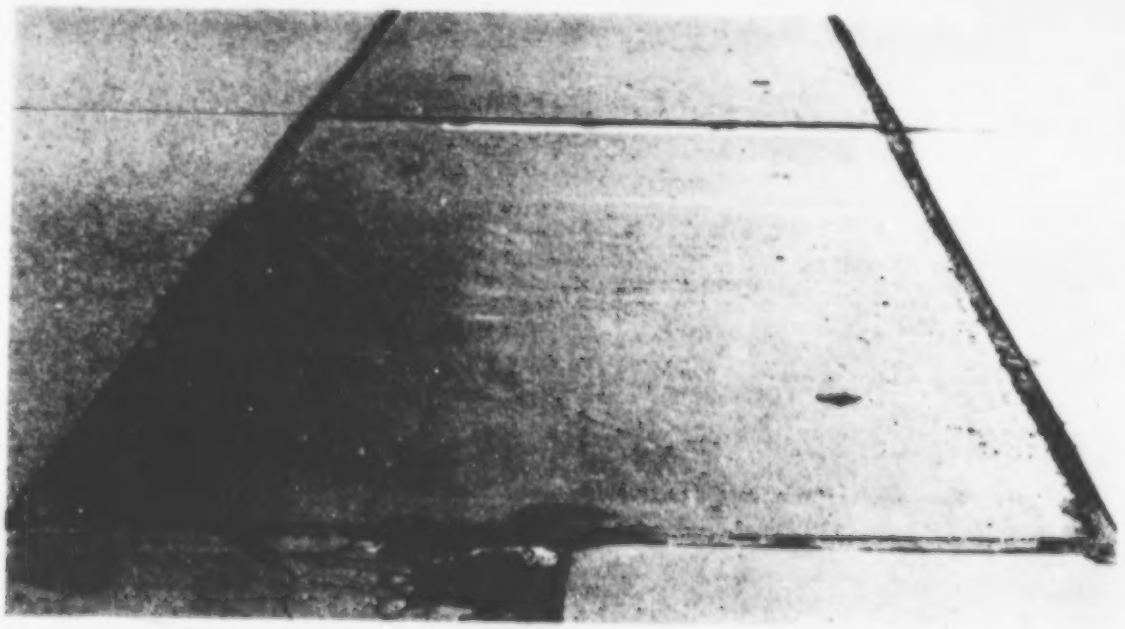


Figure 61. Precast Slab

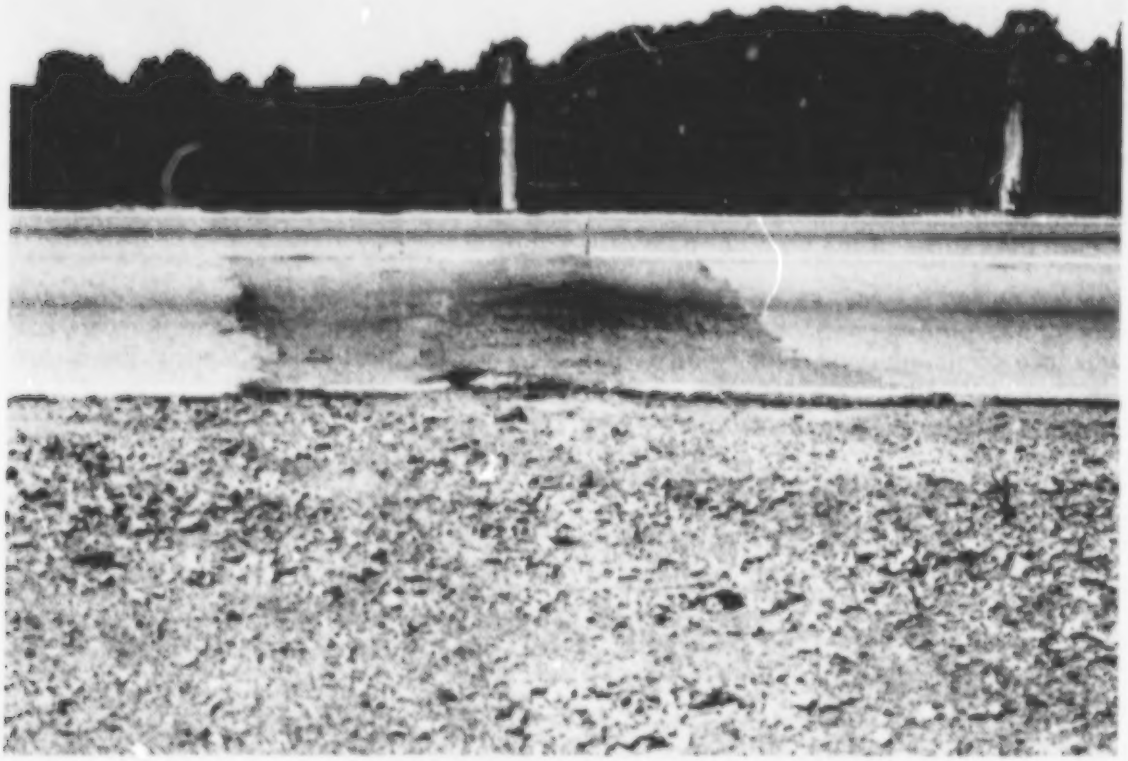


Figure 62. Cold-Mix Patching

Figure 63. Saw Cut and Hot-Mix Patching

Figure 64. Hot-Mix Patching

Table 19. Guide for Describing Density of Pavement Maintenance

Class	Uniform Description	Guidelines (Based on percent of total pavement surface area in the pavement section)
1	Few	<10%
2	Intermittent	10 - 20%
3	Frequent	20 - 50%
4	Extensive	50 - 80%
5	Throughout	80 - 100%

Appendices

Appendix A. A Guide for Completing the "Rigid Pavement Condition Evaluation Form" 59

Appendix B. A Guide for Completing "Pavement Condition Report Forms" 62

Appendix A. A Guide for Completing the "Rigid Pavement Condition Evaluation Form"

Pavement Identification
Pavement sections under evaluation must be identified by completing the following.

1. District — number of district (1 to 20).
2. Highway — number of highway.
3. Work project or contract number.
4. Work project or contract length in kilometres.
5. Location — tie into the nearest town or city, major highway interchanges, or any other prominent landmarks.
6. Date of survey — time evaluation taken place.
7. Number of evaluation sections chosen within the work project or contract limits.
8. Evaluation section's number.
9. Evaluation section's length in kilometres or metres.
10. Linear Highway Retrieval System (LHRS) numbers for evaluation section.
11. Offset distance for evaluation section as related to LHRS point.
12. Pavement surface type: specified as contrete or HL covered concrete.
13. Pavement width: from edge to edge in metres.
14. Shoulder surface type: specified as gravel, hot-mix, paved, grass, etc.
15. Shoulder width: from pavement edge to rounding in metres.

Riding Quality
Riding quality rating of evaluation section is made by driving over the pavement at posted speed and the appropriate rating is recorded in the proper column in the evaluation form (Figure A-1).

Pavement Surface Distress Manifestations
Pavement surface distress manifestations are evaluated by the rater walking and/or driving very slowly over the evaluation section and checking off all the pavement distress manifestations in their appropriate spaces (Figure A-1).

The pavement distresses are listed under six subgroups.

1.	Surface defects	- polishing - loss of coarse aggregates - pot-holes - scaling - ravelling
2.	Surface deformation	- faulting (stepping) - settlements (sagging)
3.	Joint deficiencies	- joint creeping - joint sealant loss - joint failures
4.	Cracking	- longitudinal - meandering - corner - 'D' crack - transverse - diagonal - edge crescent - miscellaneous (for any type of cracking which is not specifically described by the above)
5.	Spalling	- joint spalling - crack spalling

6. Miscellaneous distresses
   - lane separation
   - slab warping
   - wheel-track wear
   - others

Maintenance

Maintenance should be reported by its type and the density of occurrence by checking off the appropriate spaces (Figure A-1).

The performance summary based on information gathered in this "Rigid Pavement Condition Evaluation Form" is used to formulate the "Condition Rating" as given in Appendix B.

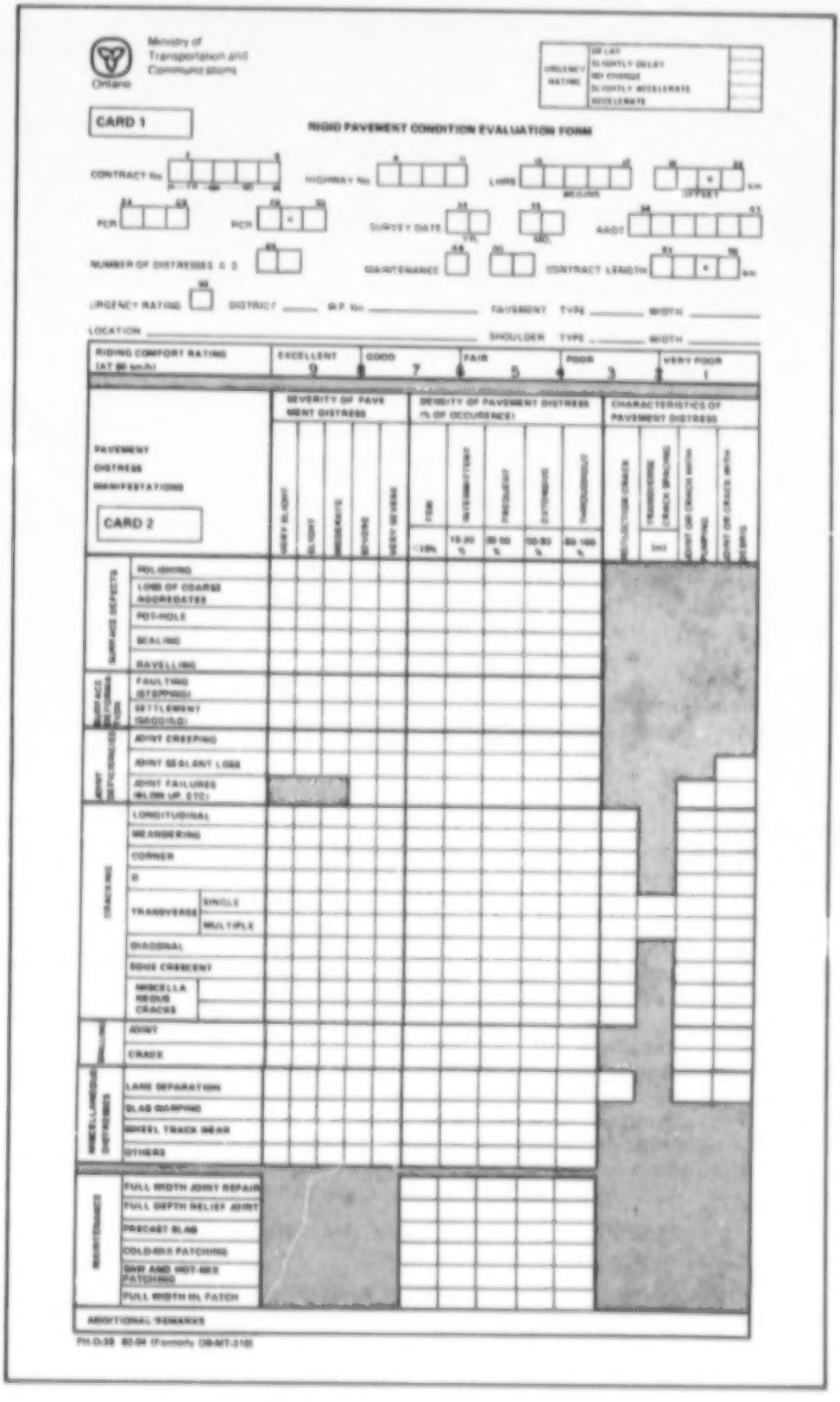


Figure A-1. Rigid Pavement Condition Evaluation Form

Appendix B. A Guide for Completing "Pavement Condition Report Forms"

District No.
Number only of district: 1 to 20.

Hwy. No.
If highway location has more than one number, list all with the lowest number first, e.g., 7, 15 and 29.

W.P. No.
List the current work project number if applicable.

Length
Indicate the length in kilometres and decimals of a kilometre. If a discrepancy occurs between the distance table or map distance and actual car distance, use actual car distance if odometer reads correctly.

Location
The location should be referenced to the junction of highways or secondary highways, or to city or town limits. Do not refer to small villages, rivers, municipal boundaries or other landmarks which are not readily identifiable on the official road map.

The sections should run from east to west or from south to north. The current MTC Reference System number of the closest numbered location to the east or south of each end of the project should be given, together with the offset distance from this location (if any).

Last Contract No.
Indicate the number or numbers of previous contracts on the section of highway. This information will be used to input and retrieval from PAMFIS.

RCR (Riding Comfort Rating)
Indicate the Riding Comfort Rating to one decimal place based on the assessment of the ride at posted speed, e.g., 6.4. The following scale developed by RTAC should be used:

10 to 8	Excellent
8 to 6	Good
6 to 4	Fair
4 to 2	Poor
2 to 0	Very poor

Pavement

Type: Indicate surface type only, i.e., gravel surface, surface treated, mulch, hot-mix, concrete, etc.

Width: Measure with tape at the time of survey. If variable, show minimum and maximum widths.

Shoulders: Estimate width or, if variable, show minimum and maximum widths.

Traffic
Indicate the year of the traffic count, the AADT and SADT and the percentage of truck traffic if known.

Soils Data
Indicate the topography and soil types. This information may be supplemented by reference to Putnam and Chapman or to the Regional soil maps, if necessary.

Pavement Structure Data
Indicate any spray patching, hot-mix patching, joint sealing, or other maintenance repair work carried out and the approximate year the work was done.

Maintenance History
Indicate any spray patching, hot-mix patching, joint sealing or other maintenance repair work carried out and approximate year work done. The extent of hot-mix patching should be noted as a percentage of the total length surveyed.

Performance and Condition
This should be indicated by a detailed summary of the riding quality, surface defects, surface deformations, joint deficiencies, and cracking. The Manual for Condition Rating of Rigid Pavements describes riding quality and various forms of pavement distress, and details the terminology to be used to describe them. The descriptive terms used in the manual have been standardized and should be strictly followed to allow accurate comparison of information from various sources.

Remarks
This section should include general comments on points such as:

- type of W.P. if this has been assigned,
- possible changes in type or volume of traffic,
- frost heaves,
- ditching,
- safety features,
- alignment, and
- possible combination with other projects.

If deflection or rebound measurements have been made to assess the strength of the pavement, the results should be indicated here. The type of measurement should be noted, i.e., Dynaflect, Benkelman Beam, etc. The data should be presented in standard form (i.e., $\bar{x} + 2\sigma$ values). The time of the survey should be noted to indicate whether the data represents the maximum spring rebound values, or if the data was taken from a single survey at some other time of year.

Roughness measurements, if any, should be indicated showing the type of machine used and the data — usually in millimetres per kilometre.

Skid resistance measurements should be shown indicating skid number values and the speed at which the skid number was assessed. The method of measurement should be indicated (i.e., brake force trailer or stereo photographs).

Proposed Remedial Measures
Indicate if patching or other maintenance measures will be adequate, and indicate the year when these should be carried out. If resurfacing is proposed, indicate the type and thickness of courses required and the extent of any padding.

Program Year
Indicate the present program year, if any, and any suggested changes. If work is required within the 5-year period, indicate the year. If no work is required at present, estimate whether work will be required in 5 to 10 years or after 10 years. This estimate is of value to the Highway Program Administration Office.

Date of Survey
Indicate the day, month and year.

Condition Rating
The attached sheet gives a guide to assessing condition rating and proposed treatments. The recommendations may be varied according to the class of highway considered.

Distribution
Distribution is made to Regional Staff. Copies should be sent to the District Office and to appropriate Head Office staff in the:

- Pavement and Foundation Design Section,
- Reference and Inventory Systems Section,
- Highway Project Control Section, and
- Research Section.

Table B-1. A Guide for the Estimation of Pavement Condition Rating and Priority for Rigid Pavements

Reconstruct within 2 years.	0 - 20	Pavement is in very poor condition with severe cracking and stepping. Frequent badly-broken and tilted slabs. Ridability is very poor. Extremely rough and uneven throughout.
Reconstruct in 2 - 3 years.	20 - 40	Pavement is in poor condition with severe cracking and stepping. Intermittent badly-broken or tilted slabs. Ridability is poor. Very rough and uneven throughout.
Cut relief joints if necessary. Resurface within 2 years.	40 - 50	Pavement is in fair to poor condition with moderate to severe stepping at cracks and joints. Ridability is fair to poor and the surface is moderately rough and uneven throughout. Occasional blow-ups may occur. Surface moderately polished by traffic.
Cut relief joints if necessary. Resurface in 2 - 5 years.	50 - 75	Pavement is in fair condition with moderate stepping at cracks and joints. Ridability is fair and the surface is slightly to moderately rough and uneven throughout. Occasional blow-ups may occur. Surface moderately polished by traffic.
Grooving or resurfacing to restore skid resistance if necessary. Otherwise normal maintenance only.	75 - 90	Pavement is in fair to good condition with slight stepping at cracks and joints. Ridability is fair to good with intermittent slightly rough sections. Surface slightly polished by traffic.
Normal maintenance only. Repair joint seals as necessary.	90 - 100	Pavement is in good condition with little cracking between joints. Intermittent slight stepping at joints. Ridability is good. Skid resistance is satisfactory.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

REGIONAL GEOTECHNICAL SECTION
PAVEMENT CONDITION REPORT

CONDITION RATING
_____

DISTRICT No. _____ HWY. No. _____ W.P. No. _____ LENGTH _____

LOCATION: _____

Reference No. From _____ To _____ Last Contract No. _____

Offset Distance _____ _____ R.C.R. _____

PAVEMENT: Type _____ Width _____ SHOULDER: Width _____

TRAFFIC: Year _____ A.A.D.T. _____ S.A.D.T. _____ % Trucks _____

SOILS DATA:

PAVEMENT STRUCTURE DATA:

MAINTENANCE HISTORY:

PERFORMANCE AND CONDITION:

REMARKS:

PROPOSED REMEDIAL MEASURES:

PROGRAM YEAR: Present _____ Suggested _____

DATE OF SURVEY: _____ PREPARED BY: _____

Figure B-1. Pavement Condition Report

POOR

QUALITY

ORIGINAL